Old Dominion University Research Foundation

FINAL REPORT

Evaluation of the Effects of AFFF Inputs on the VIP Biological Nutrient Removal Process and Pass-Through Toxicity

PHASE 1B

Submitted to:

Naval Research Laboratory

Principal Investigators: Mujde Erten-Unal, Assistant Professor
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January 1999

Project No. N00014-96-1-G021

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MEMO

Date: February 26, 1999

To: OMP - DTIC

From: Mujde Erten-Unal, Assistant Professor Mujde Erten-Unal

Re: Final Report on Project No. N00014-96-1-G021

This memo is in reference to the final report entitled "Evaluation of the Effects of AFFF Inputs on the VIP Biological Nutrient Removal Process and Pass-Through Toxicity - Phase 1B" submitted to the Naval Research Laboratory as part of the Project No. N00014-96-1-G021.

The information in Appendix B of this report provides the raw data for the project and the page numbers do not follow a specified order. They are Excel Spreadsheet files and printed separately for each set of experiment. Each experiment is submitted under a separate section specified with a cover page within Appendix B and all the data related do not have continuity on page numbers because they are different experiments.

If you have any additional questions please contact me at (757) 683-4412 or e-mail me at munal@odu.edu. Thank you for your attention.

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January 25, 1999

Defense Technical Information Center
8725 John J. Kingman Road
STE 0944
Ft. Belvoir, Virginia 22060-6218

Re: Phase IB Final Report for Project N00014-96-1-G021

Dear Sir or Madam;

Enclosed is a copy of the Volume I and Volume II of the final report entitled "Evaluation of the Effects of AFFF Inputs on the VIP Biological Nutrients Removal Process and Pass-Through Toxicity" for Phase IB of the Project N00014-96-1-G021. Along with the report a copy of the Standard Form 298 is also attached. Please call me at (757) 683-4412 or e-mail at munal@odu.edu if you have any questions.

Yours sincerely,

Mujde Erten-Unal

Mujde Erten-Unal, Ph.D.
Assistant Professor

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1.0 INTRODUCTION

1.1 Overview

A surfactant, commonly referred to as AFFF (aqueous film-forming foam), is widely used by the U.S. Navy in fire fighting water to improve the ability to control petroleum-based fires. The US Navy is exploring a number of options that include disposal of the fire fighting water to wastewater collections systems where the components of AFFF wastewater would be removed biologically. Disposal of the fire fighting foam to sanitary sewers has been considered as an option, however, concern for the potential toxic or inhibitory effects associated with AFFF wastewater have generally led to a ban from introduction of AFFF to wastewater collection systems. Present concerns over inhibitory effects of AFFF wastewater have resulted in the prohibition of its disposal to the Hampton Roads Sanitation District (HRSD) collection system where it would eventually enter one of the treatment plants that has nitrifying organisms.

Several studies have been performed on the disposal and treatment of AFFF surrogate wastewater. Bench-scale anaerobic and aerobic reactors were used to investigate the potential inhibition of the untreated and pretreated AFFF surrogates (AFFF-S) to nitrification, denitrification, and phosphorus release and uptake in a biological nutrient removal (BNR) process (CH2M Hill, 1992, 1995). The results showed that untreated AFFF-S wastewater at concentrations similar to that expected from the firefighting events exhibited measurable inhibitory effects on biological nitrification. The use of coagulants such as alum, ferric chloride, calcium chloride, and cationic polymers have also been observed to be capable of reducing the organic content of AFFF (Chan, 1978; Chan et al. 1988). Treatability studies have also been conducted with a high-purity oxygen activated sludge system (Union Carbide, 1978). The results showed 73 to 96% biological oxygen demand (BOD) removal and 69 to 76% chemical oxygen demand (COD) removal. The use of dissolved air flotation treatment on the firefighting wastewater further reduced the dilution ratio needed for acceptable effluent quality from the biological process (EG&G, 1978).

Additional studies that were performed by the Air Force to determine the biodegradability of AFFF wastewater (Lefebvre and Edward, 1973) demonstrated that nitrification was evident

and no toxicity to fathead minnows was obtained at 250 ppm AFFF concentration in the wastewater.

Application of physical-chemical treatability studies that were performed with two different types of AFFF (FC-206 and AOW-6 waste) included chemical coagulation and flocculation (precipitation), clarification, carbon adsorption, chemical oxidation and air stripping (Engineering Science, 1976). In these studies, chemical oxidation by chlorine removed only 8% COD and oxidation by potassium permanganate removed 14% of the COD. Air stripping, using both air and nitrogen sparging demonstrated only 10% COD reduction after 24-hours of aeration for both techniques.

Fenton's reagent is used for generating strong oxidants in aqueous solutions has been well documented. Studies using solutions of pure compounds and industrial wastewaters indicated very efficient destruction of the original compounds during oxidation. (Bowers et al., 1989). Fenton's reagent has been applied to treatment of several wastewaters containing organic contaminants including oxidation of di- and tri- chlorophenols in aqueous solution (Barbeni et al., 1987). Fenton oxidation has also been used to treat wastewaters containing recalcitrant compounds, including nitroaromatics and azo dyes (Mohanty and Wei, 1993).

This study was performed in two phases which will be referred to as Phase IA and Phase IB. The primary intent Phase IA was to determine the potential inhibitory effect of untreated AFFF solution on biological treatment and whether toxicity passes through to the effluent in biological treatment processes. This report contains the results of Phase 1B in which the primary intent was to determine the potential inhibitory effect of pretreated AFFF solution on the biological nutrient removal process under six different operational conditions. The two types of pretreatment included chemical oxidation with Fenton's reagent and adding different types of defoamers to AFFF wastewater. It also was investigated whether toxicity passes through to the effluent in the biological treatment process. Phase IA results have already been documented previously (NRL, 1997).

1.2.1 Objectives

The overall objective of this study was to study the impact of pretreated AFFF wastewater to a biological nutrient removal process and determine whether pass-through toxicity occurs in the effluent of a biological process receiving wastewater containing AFFF. Specific objectives of this study include:

- Determine the nitrification inhibition potential of AFFF wastewater that is pretreated with two different types of defoamers and the degree of COD removal under operating conditions similar to those of the VIP plant;

- Determine the nitrification inhibition potential of AFFF wastewater that is pretreated with Fenton's reagent and the degree of COD removal under operating conditions similar to those of the VIP plant;

- Measure the acute toxicity of the pretreated AFFF wastewater effluent to *Mysidopsis bahia* (mysid shrimp) and *Cyprinodon variegatus* (sheepshead minnow) to assess the possibility of toxicity pass through in a process similar to the VIP process.

- Examine the chemical composition of the AFFF surfactant and determine the butyl carbitol concentration in the reactors dosed with AFFF by ion chromatography and pulsed amperometric detection methods.

2.0 METHODS AND MATERIALS

2.1 Reference Reactor Operation

A 100-liter capacity fill-and-draw type batch reactor was used in order to maintain a continuous supply of uniform nitrifying microorganisms at the Environmental Engineering laboratory of Old Dominion University. The reactor operation was under cyclical anaerobic and aerobic conditions to establish and maintain a nitrifying, phosphorus-accumulating biomass that would show similar nutrient removal performance as in the VIP plant. The reference reactor consisted of a 30-gallon polyethylene tank containing a hexagonal-shaped poly vinyl chloride (PVC) air diffuser and a rapid mixer. The reactor was seeded with a target mixed liquor suspended solids concentration using sludge from the VIP plant to obtain simultaneous nitrogen and phosphorus removal. The solids were allowed to settle and the supernatant was decanted. The reactor was then fed over the duration of the study with a synthetic feed solution comprised of organic and inorganic compounds necessary to support a healthy population of nitrifying, denitrifying and phosphorus removing bacteria. This feed had the same composition used in the first Phase. Table 2-1 shows the organic and inorganic constituents used for preparing the feed solution. The feed was delivered to the reactor over the periods specified each day from a feed tank with a peristaltic pump. The feed tank consisted of a 30 gallon polyethylene tank which was placed in a refrigerator at 4^0C to limit bacterial growth.

An appropriate period of time was allowed to stabilize the reference reactor bacterial population. Reactor operation was sequenced with a programmable timer to activate mechanical mixing, aeration, solution feed, and mixed liquor and supernatant withdrawal. In Phase IA, the reactor was operated on a 4-hour cycle of aerated feed, anoxic react, aerated react, settle, and decant. In Phase IB, the aeration during the feed stage was terminated because non-aerated feed was a more

Table 2-1. Synthetic Feed Stock Constituents

Constituents	grams/gallon	Constituents	grams/gallon
Beef Extract	0.5392	$MgSO_4$	0.2242
Bactopeptone	0.7842	$CaCl_2.2H_2O$	0.0590
Urea	0.1470	NaCl	0.9836
KH_2PO_4	0.2818	K_2HPO_4	0.1103
$(NH_4)_2CO_3$	0.5563	$NaHCO_3$	0.8161
Na_2CO_3	2.2864	CH_3COOH	0.5688
$FeSO_4$	0.0246	$MnSO_4.H_2O$	0.0002
$CuSO_4$	0.00001	$Na_2MoO_4.2H_2O$	0.00001
$ZnSO_4.7H_2O$	0.0002		

representative operation mode of the VIP BNR process. React aeration, mixing, and decant were all controlled by a programmable controller. Aeration was provided through in-house air supply source and a dissolved oxygen concentration of approximately 4 mg/L was targeted during the react cycle in the reactor in Phase II. Additional mixing was supplied by a mechanical mixer. Operation of each cycle comprised of 4-hour feed with aeration, 4-hour anaerobic, 4-hour aerobic, 4-hour settle and a two-minute decant period. During each cycle, 7.5 gallons of feed was supplied and the same amount was decanted as supernatant. The total volume in the reactor was 24 gallons. The feed and supernatant were collected and analyzed for COD and ammonia nitrogen (NH_3-N) twice per week.

The reactor was also monitored for mixed liquor suspended solids (MLSS) and sludge volume index (SVI) twice per week. The COD analyses was favored over BOD as it gave very fast and repeatable results. However the BOD:COD ratio was periodically checked for both the feed and the supernatant in order to evaluate the stability of the ratio.

2.2 Analytical Methods

The analytical methods employed in this study for evaluating the effects of pretreated AFFF wastewater inputs on biological treatment performance consisted of procedures as prescribed by the United States Environmental Protection Agency (USEPA, 1979) or in Standard Methods (APWA, 1995). All chemicals used were reagent grade or better and all quality assurance/quality control procedures were followed as closely as possible.

Measurements of organic strength were determined through carbonaceous five day BOD ($CBOD_5$) and COD measurements. $CBOD_5$ (determined with a nitrification inhibitor added to BOD bottles) were measured to eliminate potential interferences that nitrification could have on the

evaluation of organics removal with the BOD test. CBOD, and COD analyses were determined using filtered samples on reactor effluent and filtered and unfiltered samples in the influent. Samples were filtered through a glass fiber filter to eliminate microorganisms and other particulate materials that are not related to the organic components of the AFFF or the dissolved organic compounds that are in the wastewater before AFFF introduction. Since the AFFF components are water soluble and will be dissolved in solution, filtration should not directly interfere with their accurate detection. Measurements of total suspended and volatile suspended solids (TSS and VSS, respectively) were used to determine organic solids loading, reactor MLSS and mixed liquor volatile suspended solids (MLVSS) concentrations, and non-settleable TSS concentrations in reactor effluent. In order to reduce variability of TSS and VSS data, the tests were performed on the same days that solids concentrations were fed into the reactor. The nitrogen series were determined by three different analytical techniques. Persulfate digestion followed by ammonia analysis by ion selective electrode was utilized to determine total Kjeldahl nitrogen (TKN) concentrations, ammonia concentrations were measured by ion selective electrode without sample digestion, and nitrate and nitrite concentrations were determined on filtered samples using ion chromatography. Orthophosphate was similarly determined using ion chromatography.

Butyl Carbitol Analysis

As part of this study, butyl carbitol, a major component of AFFF, was also analyzed by ion chromatography utilizing electrochemical detection. Although AFFF from 3M Corporation was used in this study, there are three other Navy-approved manufacturers of AFFF and they have different amounts of butyl carbitol in their product. The AFFF from 3M Corporation was the most readily

available product during this study. The Material Safety Data Sheet for AFFF, obtained from its manufacturer 3M Corporation, indicates that butyl carbitol (CAS # 112-34-5) is present as diethylene glycol monobutyl ether at 30 percent by volume. The method used was the one developed by the Dionex Corporation which measured alcohols by Pulsed Amperometric Detection (PAD).

In this method, a potential is applied to an electrode (a gold electrode in this case) in which the amperometric cell current is integrated and electrons are actually transferred between the analyte molecules and the electrode. The detector output is then reported for the integration period. Repetitive series of potentials or a user programmed waveform provided by Dionex is applied to the cell. A waveform includes a series of oxidation reduction potentials which sets the beginning and end of the integration period as shown in Figure 2-1. In amperometric detection method, the potential difference between the electrode and the solution is high enough to cause electron transfer reactions to occur which oxidizes or reduces the species in solution. During an oxidation reaction, electrons are transferred from the analyte to the electrode whereas during reduction, the reverse occurs. During a sample run, two eluants, 90/10 Acetonitrile/water and 100% water were used. A 0.3 M NaOH solution was used as a post column reagent and OmniPac PAX-500 columns were used as analyte columns. The eluant solutions were applied by using linear gradient method. A graphical representation of the linear gradient method is shown in Figure 2-2. A copy of the method used in butyl carbitol determination is also attached in Appendix A.

The procedure used in method development consisted of initially determining the time at which the peak for a known concentration of pure butyl carbitol would elute and then determining the concentration of any peak that would elute at the same retention time for the samples containing AFFF. To rule out any interferences that may be caused from any constituent that would elute at the

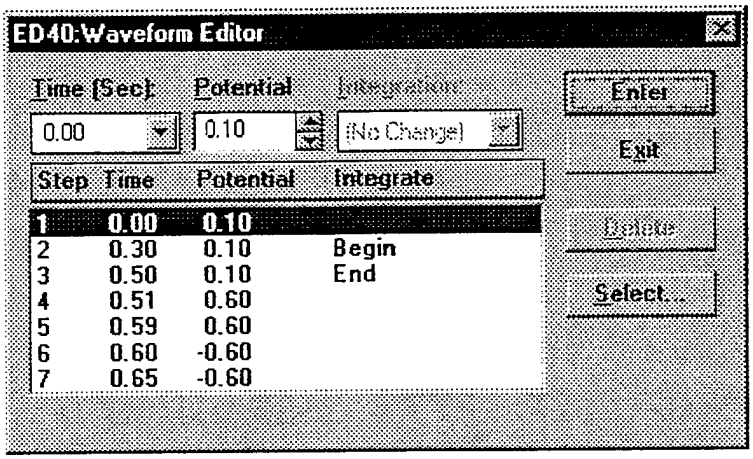


Figure 2-1. Waveform Editor

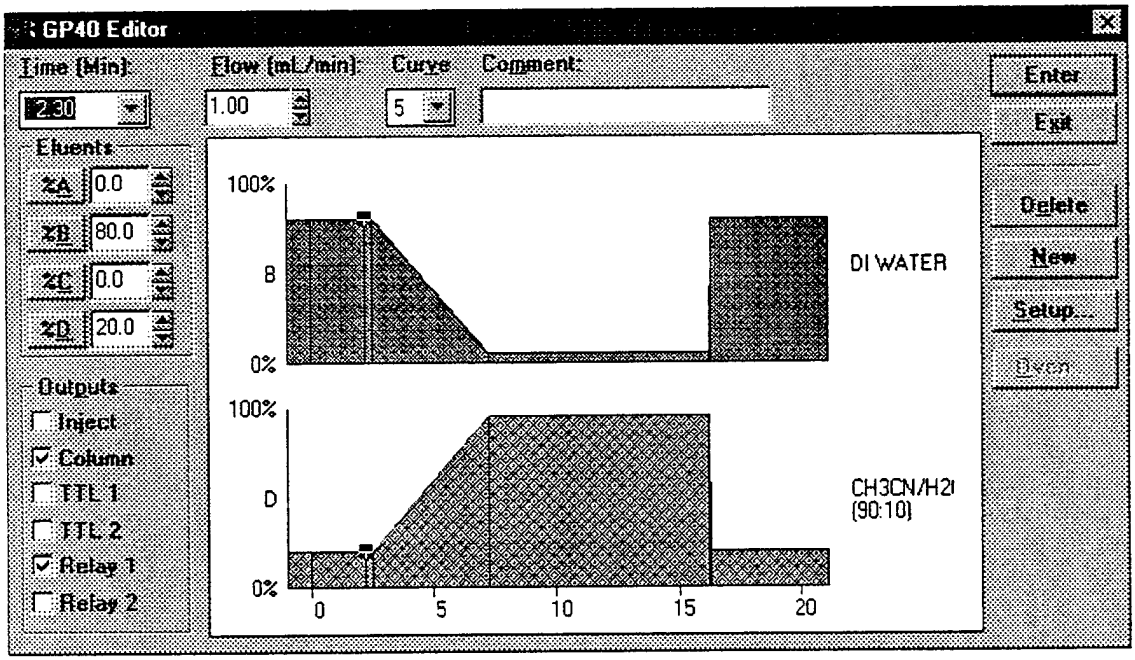


Figure 2-2. Graphical Representation of Linear Gradient Method

same retention time, the synthetic feed solution sample, and the samples from the control reactors which contained no AFFF were also tested with the same method. Results of the test method are also attached in Appendix A. The results attached were obtained from inhibition test samples with 60 ppm AFFF and Defoamer AF9020. Pure butyl carbitol was tested at concentrations of 1 ppm, 10 ppm, and 50 ppm. This range was used since the AFFF concentration tested was only 60 ppm and the butyl carbitol concentration in AFFF was only 30% by volume.

2.3 BNR Inhibition Batch Assays

In Phase II, six nitrification inhibition tests were performed. Of the six, three inhibition tests investigated the effect of defoamers on the treatability of AFFF, and the other three investigated the use of Fenton's reagent on removal of AFFF organic strength and nitrification inhibition. The two defoamers tested were Defoamer DF8710, which is currently used by the Navy, and Defoamer AF9020 which was recommended by the manufacturer of AFFF used in this study. The inhibition tests started with 60 ppm AFFF concentration since this level was identified as the threshold concentration for nitrification inhibition in Phase IA. Specific doses of each defoamer were added in proportion to eliminate any foaming caused by AFFF during the aerated operational stage of the inhibition test.

Fenton's reagent, a strong oxidizing agent, was also investigated as another pretreatment option to determine its effects on COD removal by mixing AFFF laden wastewater with appropriate dose of Fe^{2+} and H_2O_2 (Fenton's reagent) for 24-hours period. Fenton's reagent is formed as a result of the reaction of hydrogen peroxide and iron (II) to generate hydroxyl radical (Watts et al., 1992). Residual H_2O_2 was neutralized with sodium bisulfite. The pH of this pretreated wastewater was then

adjusted to 7.0 by adding sodium hydroxide and this was then blended with synthetic feed solution before it was fed to the reactors. As in Phase IA, three control reactors with no AFFF, no defoamers or Fenton's reagent were used to compare with the inhibition reactors. Three AFFF concentrations of 60ppm, 120 ppm, and 480 ppm were pretreated with Fenton's reagent. The sixth inhibition test was conducted to investigate the effects of the defoamer alone itself on the nitrification process. In this test, two control reactors i.e., no AFFF, no defoamer; two reactors with defoamer alone, and two reactors with 120 ppm AFFF concentration and appropriate dose of defoamers were used.

The first two inhibition tests that were conducted to evaluate the effect of defoamers at 60ppm concentrations were conducted for a period of 8 hours with 2 hour cycles of each anaerobic feed, anaerobic, aerobic and settle period. However the remaining four tests were conducted with one of the three control and one of the three inhibitions reactors being run for an extended 2 hour aerobic cycle

2.4 Toxicity Pass-Through Testing

Toxicity pass-through testing was performed on the inhibition reactors in Phase IB to estimate the maximum loading of the pretreated AFFF wastewater to the VIP plant without increasing effluent toxicity at the VIP plant. The acute toxicity pass-through tests were conducted using the procedures outlined by the EPA (USEPA, 1989). At the end of the BNR inhibition batch aeration period, the mixed liquor was allowed to settle and clarified supernatant was decanted from each reactor and filtered through a coarse glass fiber filter. Toxicity samples were submitted to a qualified bioassay laboratory for acute toxicity testing using *M. bahia* and *C. variegatus* following the current EPA procedures.

3.0 RESULTS

3.1 Reference Reactor Performance

The reference reactor was operated for 16 weeks and monitored for MLSS, SVI, COD, ammonia nitrogen, and TKN on a semi-weekly basis (Table 3-1). Collection of influent and effluent (supernatant) samples and the mixed-liquor allowed calculation of COD and ammonia removal as well as the food-to-microorganisms (F/M) ratio.

The average COD removal was approximately 95% while removal for ammonia-nitrogen averaged 96%. Throughout Phase IB, the reference reactor exhibited very good nitrification. Even at times when there was a sharp increase in the feed ammonia concentrations, there was no inhibition to nitrification. In Phase IB, the reference reactor operation did not include aeration during the feed cycle. This was determined to be more representative of the VIP BNR process. There were no major operational problems during this phase and the reactor operated continuously for sixteen weeks without any disruption. The SVI values of the reactor were steady averaging 132 mL/gram and the sludge had good settling characteristics.

The reactor was also monitored for pH during the different stages of operation. The pH of the feed solution was maintained at approximately 6.7 with a bicarbonate alkalinity of approximately 300-400 mg/l as calcium carbonate. The pH during the various cycles ranged from 7.5 to 7.8. The alkalinity of the supernatant was about 100-150 mg/l as calcium carbonate. Alkalinity of the feed was sufficient to provide good nitrification throughout this phase of the study. The dissolved oxygen (DO) concentration was also continuously monitored during the different stages of the reactor operation. The average DO values ranged between 0.5 to 1.0 mg/L during the feed stage; 0.15 to 0.10 mg/L during the anaerobic stage; and 5.5 to 6.0 mg/L during the aeration stage of the reactor

TABLE 3.1 : Weekly Performance of the Reference Reactor during the Phase IB Study

Week	MLSS	MLVSS	COD mg/l		% COD	Ammonia Nitrogen, mg/l		TKN, mg/l		SVI
	mg/l	mg/l	Feed	Super.	removal	Feed	Supern.	Feed	Supern.	mL/gram
1	3020	2820	871	38	95.7	43.00	0.86	170.0	10.70	68
	2560	2128	932	27	97.1	28.20	~	241.0	~	88
2	2704	2348	820	40	95.1	28.20	0.46	147.0	6.50	102
	3616	3136	871	43	95.1	20.90	0.48	202.0	7.90	76
3	4512	3292	748	40	94.6	23.10	0.36	380.0	16.20	78
	4584	3460	1025	45	95.6	20.60	0.31	338.0	14.40	98
4	4844	3684	1025	63	93.8	86.20	1.92	210.7	28.20	114
	4716	3636	1025	40	96.1	113.40	2.52	380.6	33.00	127
5	4884	3716	1035	43	95.9	38.30	0.96	636.9	49.70	133
	5096	4044	968	30	96.9	86.60	1.53	688.9	26.60	137
6	4324	3380	997	43	95.7	30.50	1.58	149.3	1.56	162
	4808	3872	1020	50	95.1	~	~	~	~	146
7	4904	3832	1002	12	98.8	32.90	1.27	132.4	0.84	153
	3976	3148	1040	20	98.1	75.70	23.02	110.1	1.61	163
8	4276	3556	1012	53	94.8	32.20	0.10	80.7	11.90	152
	5852	4788	984	32	96.7	~	~	~	~	120
9	5068	4024	1009	81	92.0	53.70	0.92	106.8	3.09	138
	5628	4804	1063	102	90.4	49.60	0.43	126.6	3.26	124
10	5488	4748	1061	63	94.0	~	~	~	~	146
	4984	3716	1104	43	96.1	~	~	~	~	150
11	5152	4312	1127	48	95.8	12.15	0.82	61.0	0.95	146
	5040	4680	1025	61	94.1	11.69	0.89	61.0	1.00	149
12	4908	4104	991	53	94.7	26.70	0.10	25.7	1.00	143
	5028	4156	1050	66	93.7	~	~	~	~	139
13	4976	4080	1020	68	93.3	~	~	~	~	131
	4408	3544	1056	81	92.3	~	~	~	~	159
14	4364	3496	1009	61	94.0	20.70	0.40	102.9	2.20	160
	3788	3012	~	~	~	~	~	~	~	172
15	4172	3328	~	~	~	23.30	0.20	39.2	1.50	156
	4756	3920	1053	81	92.3	~	~	~	~	126
16	3360	2764	~	~	~	34.60	0.10	140.7	1.80	149
	3760	2972	991	38	96.2	~	~	~	~	133
Average	**4486**	**3641**	**998**	**51**	**95**	**41**	**1**	**206**	**11**	**132**

~ : Data not available

operation. The DO was adjusted by changing the flow of air which was measured with the help of a flow meter, attached to the air supply line.

3.2 Butyl Carbitol Analysis

The chromatograph obtained for the butyl carbitol concentrations tested did not show any prominent peaks with the exception for the chromatograph for 50 ppm AFFF concentration. Two prominent peaks were seen at retention times of 1.68 minutes and 2.17 minutes. This indicated that the concentrations tested were low enough to be detected however, the butyl carbitol was not 100% pure. A similar prominent peak was seen at 1.68 retention time in chromatographs obtained for the synthetic feed solution. Samples from the control reactors were also measured under the respective peaks which had lower areas under each peak as shown Appendix A. On the other hand, prominent peaks with comparatively larger areas were seen in samples from the inhibition reactors at around the same retention time. However, the data was not sufficient enough to determine that these peaks belonged to butyl carbitol or there was any type of interference because similar type of peaks were also observed at the same retention time at samples obtained from the control reactors and from the feed solution which did not contain any AFFF.

3.3 BNR Inhibition Batch Assays Pretreated with Defoamers

A study that was conducted previously as an independent study in the laboratory tested six to eight defoamers that were recommended by 3M as possible candidates for curtailing the foaming caused by AFFF. The study consisted of a batch reactor with 4 hours of aeration. A screening analysis was performed and showed that 7.5 milliliters/liter of concentrated defoamer was needed to

curtail the foaming attributable to 80 mg/L of AFFF. In addition, the dosage of defoamer required to curtail the foaming attributable to 80 mg/L of AFFF exerted a COD of approximately 4,700 mg/L. It was also observed that even with 7.5 mls/liter of defoamer added to the mixed liquor in the inhibition reactors, foaming increased over the course of 4 hours of biological treatment.

The results of this study showed that some defoamers worked better than others. Based on these results, a defoamer that exhibited the most successful results as well as the defoamer that the Navy is currently using were incorporated in the nitrification inhibition batch assay experiments. Since the Phase 1A results showed excessive foaming at 50 and 60 ppm AFFF, the two defoamers were tested for 60 ppm AFFF concentration where foaming was the most excessive. The data for the inhibition testing with the defoamers are shown in Appendix B.

3.3.1 Pretreatment with Defoamer 8710

Triplicate reactors were setup for controls and triplicate reactors were setup for 60 ppm AFFF pretreated with Defoamer 8710 which is currently used by the Navy at Oceana Naval Air Station to suppress the foaming caused by AFFF. The conditions of this inhibition test are shown in Table 3-2. The results did not show any significant solids washout in both control and inhibition reactors. The ammonia nitrogen removal rates were around 72 percent for the control reactors. However, there was significant nitrification inhibition with 60 ppm AFFF pretreated with Defoamer 8070 as compared to the control reactors as shown in Table 3-3. There was no ammonia removal in all of the inhibition reactors. Nitrate levels in the effluent were also less than 5 mg/L indicating that not much ammonia was converted to nitrate and lack of nitrification for the inhibition reactors. However, the operation of the inhibition reactors were changed from aerated feed cycle to non-aerated feed cycle in Phase

TABLE 3-2—BNR Inhibition Reactor 60 ppm AFFF Components Pretreated with Defoamer 8710

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	3,320	3,347	3,260	3,900	3,900	3,713
Batch MLVSS (mg/L)	3,047	3,027	2,940	3,393	3,400	3,233
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	60	60	60
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	4.0	4.0	4.0
Volume of defoamer 8710 added (mL)	0	0	0	75	75	75
Volume of Synthetic Feed Solution for the simulated wastewater (mL)	2,000	2,000	2,000	1,921	1,921	1,921

TABLE 3-3 — Nitrification Inhibition at 60 ppm AFFF Pretreated with Defoamer 8710

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal NH_3 - N	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	30.50			0.70.		1,190		
Reference Reactor Decant	0	1.58			30.1		5.9		
Control (A1)	0	21.25	5.85	72.4	0.7	23.3	401	32.2	92.0
Control (A2)	0	21.25	6.32	70.3	0.7	25.1	401	58.5	85.4
Control (A3)	0	19.62	5.20	73.5	0.7	25.1	401	32.2	92.0
AFFF (B1)	60	17.41	22.99	-32.0	2.6	3.0	1801**	927	48.6
AFFF (B2)	60	16.73	22.11	-32.0	1.2	4.1	1801**	914	49.3
AFFF (B3)	60	16.73	22.11	-32.0	0.7	3.2	1801**	979	45.6

* Initial values correspond to the measurements taken at the end of feeding stage. (end of 2 hours)

** Corresponds to the total COD which includes Reference Reactor Decant = 5.9 mg/L, Feedstock COD = 1190 mg/L, AFFF COD = 1,737 mg/L, and Defoamer 8070 COD = 4,930 mg/L.

IB. The inhibition test results for Phase IA, showed that there was significant ammonia removal during the initial aerated feed stage. Therefore, the reduction in nitrification may be attributed to the change in the operation mode of the reactors. The COD removal rates were higher for the control reactors ranging between 85 to 92 percent. For the inhibition reactors, the COD removal rates were significantly lower than the control reactors ranging between 45 to 49 percent. The air supply to each reactor was monitored during the react phase with submergible dissolved oxygen probe to ensure that appropriate amount of dissolved oxygen was provided.

3.3.2 Pretreatment with Defoamer AF9020

Defoamer AF9020 was recommended by the manufacturer during the initial screening period. The results of the initial screening study showed that Defoamer AF9020 had more successful results, therefore it was used in the inhibition tests. The conditions of the inhibition test are summarized in Table 3-4. During the testing, there was no significant loss in the solids in both control and inhibition reactors. The ammonia nitrogen removal rates were much lower for the inhibition reactors than the controls ranging between 28 to 49 percent indicating nitrification inhibition as shown in Table 3-5. The COD removal rates were also significantly lower for the inhibition reactors (47 to 56 %) when compared to the control reactors (88 to 98%). This inhibition test was also performed under non-aerated feed conditions, however, the nitrification potential was better than Defoamer 8710. The oxygen uptake rates were lower for the inhibition reactors when compared to the control reactors as shown in Appendix B.

TABLE 3-4—BNR Inhibition Reactor 60 ppm AFFF Components Pretreated with Defoamer AF9020

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	2,993	2,993	2,813	3,413	3,333	3,620
Batch MLVSS (mg/L)	2,667	2,620	2,520	3,033	2,960	3,213
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	60	60	60
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	4.0	4.0	4.0
Volume of defoamer AF9020 added (mL)	0	0	0	15	15	15
Volume of Synthetic Feed Solution for the simulated wastewater (mL)	2,000	2,000	2,000	1,981	1,981	1,981

TABLE 3-5 — Nitrification Inhibition at 60 ppm AFFF Pretreated with Defoamer AF9020

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal NH_3 - N	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	26.70			0.9		1,125		
Reference Reactor Decant	0	0.10			24.3		104.3		
Control (A1)	0	24.6	2.8	88.6	0.8	19.0	444.5	10.3	97.7
Control (A2)	0	24.0	3.2	86.7	0.8	22.1	444.5	23.7	94.7
Control (A3)	0	25.7	2.8	89.1	0.8	17.0	444.5	50.6	88.6
AFFF (B1)	60	22.3	11.3	49.3	0.8	13.5	1,907**	1004	47.3
AFFF (B2)	60	23.5	13.2	44.4	0.8	9.0	1,907**	830	56.5
AFFF (B3)	60	21.4	15.4	28.0	0.8	13.8	1,907**	964	49.5

* Initial values correspond to the measurements taken at the end of feeding stage. (end of 2 hours)

** Corresponds to the total COD which includes Reference Reactor Decant = 104.3 mg/L, Feedstock COD = 1125 mg/L, AFFF COD = 1,737 mg/L, and Defoamer AF9020 COD = 5,300 mg/L.

3.3.3 Pretreatment with Best Performing Defoamer

Another inhibition test was also performed with the best performing defoamer (Defoamer AF9020) at 120 ppm AFFF concentration. The sequence of the regular inhibition test was changed with this set. In the previous tests, significant nitrification inhibition was noted in reactors containing AFFF and defoamers. Nitrification was achieved successfully in the control reactors. The nitrification inhibition in the reactors containing AFFF wastewater and defoamer could be attributed both due to the presence of defoamers as well as AFFF. Therefore, this test was conducted using duplicate reactors instead of triplicates. There was duplicate set of control with no defoamers or AFFF, one duplicate set with defoamers only, and one duplicate set with both defoamers and 120 ppm AFFF. One of the main reasons for conducting the test in this fashion was to evaluate whether it was AFFF or the defoamer that would contribute to toxicity pass-through during the toxicity testing. The aeration stages of one of each set were also extended for additional two hours in order to verify the effects of additional aeration on improvements in nitrification potential.

The test conditions are shown in Table 3-7. The inhibition results are also shown in table 3-8 with significant improvement in nitrification potential in all of the reactors that had extended aeration during the react stage. For example, ammonia removal rates were greater than 99 percent for the control, 99.5 percent for the reactor with defoamer only, and 99.6 percent for the reactor containing both defoamer and 120 ppm AFFF.

The nitrate values were also the highest for all of the extended aeration reactors indicating good nitrification potential. However, COD reduction did not follow the trend and exhibited no reduction in the reactors containing 120 ppm AFFF. The COD of the 120 ppm AFFF itself also increased significantly which might have contributed to the low removal rates.

TABLE 3-6—BNR Inhibition Reactor 120 ppm AFFF Components Pretreated with Best Performing Defoamer *Extended Aeration* of React Phase with Defoamer AF9020

PARAMETER	CONTROL REACTORS		DEFOAMER ONLY		120 ppm AFFF and DEFOAMER	
	A_1	A_2	B_1	B_2	C_1	C_2
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	3,167	3,193	5,073	4,710	4,800	4,960
Batch MLVSS (mg/L)	2,767	2,647	4,480	4,020	4,140	4,220
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	0	120	120
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	0.0	8.0	8.0
Volume of defoamer AF9020 added (mL)	0	0	30	30	30	30
Volume of Synthetic Feed Solution for the simulated wastewater (mL)	2,000	2,000	1,970	1,970	1,962	1,962

TABLE 3-7 — Nitrification Inhibition at 120 ppm AFFF Pretreated with Best Performing Defoamer *Extended Aeration* of React Phase with Defoamer AF9020

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal NH_3 - N	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	32.2			1.1		1,102		
Reference Reactor Decant	0	0.10			17.7		38.4		
Control (A1) *Extended Aeration Reactor*	0	26.3	0.01	99.9	0.9	31.1	393	38.4	90.2
Control (A2)	0	23.3	2.2	90.6	0.9	15.7	393	115.3	70.7
Defoamer Only (B1)	0	20.7	2.9	86.0	0.9	21.3	1276	615	51.8
Defoamer Only (B2) *Extended Aeration Reactor*	0	19.9	0.1	99.5	1.0	27.7	1,276	692	45.8
AFFF (C1)	120	20.7	6.6	68.1	0.9	18.5	2,408**	2,486	-3.2
AFFF (C2) *Extended Aeration Reactor*	120	19.9	0.07	99.6	0.9	28.2	2,408**	2,588	-7.5

* Initial values correspond to the measurements taken at the end of feeding stage. (end of 2 hours)

** Corresponds to the total COD which includes Reference Reactor Decant = 38.4 mg/L, Feedstock COD = 1,102 mg/L, AFFF COD = 3,396 mg/L, and Defoamer AF9020 COD = 5,300 mg/L.

3.4 BNR Inhibition Batch Assays Pretreated with Fenton's Reagent

In this part of the phase 1B study, the nitrification inhibition potential of AFFF pretreated with Fenton's Reagent were evaluated. The AFFF:H_2O_2:Fe^{2+} ratios that were required to achieve appreciable reductions in foaming and AFFF concentrations were determined. Since the direct measurement of AFFF was difficult and was not a possible dosing parameter at that point, the study assessed the required COD:H_2O_2:Fe^{2+} ratio needed to achieve appreciable reductions in foaming and the COD of the wastewater containing AFFF. Three different concentrations of wastewater containing 60 ppm, 120 ppm and 480 ppm AFFF were pretreated with Fenton's reagent and the data are attached in Appendix C.

3.4.1 Pretreatment with Fenton's Reagent at 60 ppm AFFF

The wastewater containing 60 ppm AFFF was pretreated with Fenton's reagent 24 hours prior to the inhibition test. The test conditions with the concentrations of iron and hydrogen peroxide are shown in Table 3-8. There was no significant loss of mixed liquor solids from the reactor. The inhibition test results are tabulated in table 3-9. At 60 ppm AFFF, the ammonia removal rates for the extended aeration inhibition reactors (99.4%) were as high as the control reactors (99.5%). The ammonia nitrogen removal rates for the inhibition reactors operating in non-extended aeration mode were only 10 percent lower than the control reactors. Nitrate concentration in the extended aeration inhibition reactor was higher than the control reactor operating under similar conditions which indicated good nitrification potential. The COD removal rates were greater than 89 percent in all of the reactors indicating the strong oxidation potential of Fenton's reagent.

TABLE 3-8—BNR Inhibition Reactor 60 ppm AFFF Components Pretreated with Fenton's Reagent

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	2,793	2,893	2,807	2,880	2,760	2,740
Batch MLVSS (mg/L)	2,480	2,460	2,433	2,880	2,367	2,460
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	120	120	120
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	8.0	8.0	8.0
Fe^{2+} Concentration (mg/L) *Fenton's Reagent*	0	0	0	300	300	300
H_2O_2 Concentration (mg/L) *Fenton's Reagent*	0	0	0	3,000	3,000	3,000

TABLE 3-9 — Nitrification Inhibition at 60 ppm AFFF Pretreated with Fenton's Reagent

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal NH_3 - N	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	20.7			0.8		973.5		
Reference Reactor Decant	0	0.4			14.8		53.0		
Control (A1) *Extended Aeration*	0	20.7	0.1	99.5	0.8	33.8	360	26.3	92.6
Control (A2)	0	20.7	5.3	74.4	0.8	17.1	360	26.5	92.6
Control (A3)	0	19.9	4.9	75.4	0.8	16.9	360	13.3	96.3
AFFF (B1) *Extended Aeration*	60	16.3	0.1	99.4	0.8	37.4	846**	92.9	89.0
AFFF (B2)	60	16.3	6.0	63.2	0.8	N/A	846 **	79.6	90.6
AFFF (B3)	60	16.3	6.5	60.1	0.8	N/A	846**	79.6	90.6

* Initial values correspond to the measurements taken at the end of feeding stage. (end of 2 hours)

** Corresponds to the total COD which includes Reference Reactor Decant = 53 mg/L, Feedstock COD = 973.5 mg/L, Fenton's Treated AFFF COD = 1,459 mg/L.

3.4.2 Pretreatment with Fenton's Reagent at 120 ppm AFFF

The reactor components for this inhibition test are shown in table 3-10. There was little or no solids loss in inhibition reactors when compared to the control reactors. The results showed no nitrification inhibition for the reactors operating in extended aeration mode for both controls and inhibition sets. The ammonia removal rates were 99.6 percent for both sets and nitrate production rates were high in both inhibition and control reactors indicating good nitrification as shown in Table 3-11. The COD removal rates were not as high for the inhibition reactors as compared to the control reactors in both non-extended and extended aeration operation modes possibly due to the higher COD of the pretreated AFFF.

3.4.3 Pretreatment with Fenton's Reagent at 480 ppm AFFF

The concentration of AFFF was increased to 480 ppm to determine if there was significant inhibition in nitrification after Fenton's oxidation as pretreatment. The test conditions are shown in Table 3-12. There was no significant loss in the solid concentrations between the control reactors and inhibition reactors. The inhibition test results showed that nitrification potential decreased by 50 percent even in the inhibition reactor operating in extended aeration mode when compared to the control reactor with similar operational mode. Even though in the remaining control reactors the ammonia removal rates were not as high (ranging from 64 to 67%), the ammonia removal in the inhibition reactors were still 50 percent less than that of control reactors which indicated nitrification inhibition (Table 3-13). The COD removal rates for the inhibition reactors decreased significantly at all operational modes when compared to the control reactors. The COD of 480 ppm AFFF

TABLE 3-10—BNR Inhibition Reactor 120 ppm AFFF Components Pretreated with Fenton's Reagent

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	2,973	3,040	2,927	2,900	2,940	2,800
Batch MLVSS (mg/L)	2,627	2,727	2,640	2,647	2,653	2,473
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	60	60	60
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	4.0	4.0	4.0
Fe^{2+} Concentration (mg/L) *Fenton's Reagent*	0	0	0	300	300	300
H_2O_2 Concentration (mg/L) *Fenton's Reagent*	0	0	0	3,000	3,000	3,000

TABLE 3-11 — Nitrification Inhibition at 120 ppm AFFF Pretreated with Fenton's Reagent

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal NH_3 - N	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	34.6			0.9		1,082		
Reference Reactor Decant	0	0.1			17.4		54.1		
Control (A1) *Extended Aeration*	0	25.2	0.1	99.6	1.0	30.4	397	13.5	96.6
Control (A2)	0	26.3	0.5	98.1	1.0	19.0	397	13.5	96.6
Control (A3)	0	27.3	0.5	98.2	0.9	15.9	397	13.5	96.6
AFFF (B1) *Extended Aeration*	120	27.3	0.1	99.6	0.9	31.0	1,276**	338	73.5
AFFF (B2)	120	42.6	12.3	71.1	0.9	28.6	1,276**	325	74.6
AFFF (B3)	120	56.6	9.8	82.7	1.0	28.4	1,276**	284	77.7

* Initial values correspond to the measurements taken at the end of feeding stage. (end of 2 hours)

** Corresponds to the total COD which includes Reference Reactor Decant = 54.1 mg/L, Feedstock COD = 1,082 m/L, Fenton's Treated AFFF COD = 2,638 mg/L.

TABLE 3-12—BNR Inhibition Reactor 480 ppm AFFF Components Pretreated with Fenton's Reagent

PARAMETER	CONTROL REACTORS			INHIBITION REACTORS		
	A_1	A_2	A_3	B_1	B_2	B_3
Total Reaction Volume (mL)	6,000	6,000	6,000	6,000	6,000	6,000
Batch MLSS (mg/L)	2,667	2,593	2,587	2,153	2,347	2,493
Batch MLVSS (mg/L)	2,440	2,413	2,380	1,927	2,073	2,253
Seed Biomass Volume (ml)	4,000	4,000	4,000	4,000	4,000	4,000
Effective wastewater (feed & AFFF) Volume, ml	2,000	2,000	2,000	2,000	2,000	2,000
AFFF Concentration (ppm)	0	0	0	480	480	480
AFFF Volume for the simulated wastewater (mL)	0.0	0.0	0.0	32	32	32
Fe^{2+} Concentration (mg/L) *Fenton's Reagent*	0	0	0	300	300	300
H_2O_2 Concentration (mg/L) *Fenton's Reagent*	0	0	0	3,000	3,000	3,000

TABLE 3-13 — Nitrification Inhibition at 480 ppm AFFF Pretreated with Fenton's Reagent

Reactor	AFFF ppm	*Initial NH_3 - N mg/L	Final NH_3 - N mg/L	% Removal NH_3 - N	*Initial NO_3 - N mg/L	Final NO_3 - N mg/L	Initial COD mg/L	Final COD mg/L	COD Removal %
Feedstock	0	23.3			0.9		1,038		
Reference Reactor Decant	0	0.2			3.4		13.1		
Control (A1) *Extended Aeration*	0	18.3	0.1	99.5	1.1	30.7	346	26.3	92.4
Control (A2)	0	17.6	5.8	67.0	0.9	13.9	346	39.4	88.6
Control (A3)	0	17.6	6.2	64.8	0.9	15.0	346	13.1	96.2
AFFF (B1) *Extended Aeration*	480	15.0	6.8	54.7	0.8	17.0	3,352**	2,575	23.2
AFFF (B2)	480	15.0	9.3	38.0	0.8	11.2	3,352**	2,680	20.0
AFFF (B3)	480	14.4	9.7	32.6	0.9	14.0	3,352**	2,706	19.3

* Initial values correspond to the measurements taken at the end of feeding stage. (end of 2 hours)

** Corresponds to the total COD which includes Reference Reactor Decant = 13.1 mg/L, Feedstock COD = 1,038 m/L, Fenton's Treated AFFF COD = 9,012 mg/L.

wastewater pretreated with Fenton's reagent was 9,000 mg/L which contributed greatly to the organic strength of the wastewater. The COD removal rates for the inhibition reactors ranged between 19 to 23 percent indicating biological degradation inhibition as well.

3.5 Toxicity Pass-Through Testing

The results of effluent toxicity pass-through tests conducted with the mysid shrimp and sheepshead minnow are shown in Table 3-14. In the samples in which AFFF was treated with the defoamers, the minnows were less sensitive to the effluent and exhibited toxicity only in one sample with 120 ppm AFFF pretreated with the best performing defoamer. However, the mysids were much more sensitive and the effluent exhibited toxicity in all of the inhibition reactors pretreated with the two types of defoamers. The results showed that Defoamer 8710 LC_{50} values (65 to 72%) were higher than the defoamer AF9020 (LC_{50}'s between 45-50%) indicating the organisms' less sensitivity to the defoamer that is currently used by NAS Oceana. The tests conducted in duplicates showed that there was no pass-through toxicity in the reactors that had defoamer only, however, pass-through toxicity was observed to both minnows and mysid shrimp in the reactors containing AFFF + Defoamer AF9020. This indicated the possibility that the toxic component of the effluent was AFFF rather than the defoamers.

For the inhibition reactors containing AFFF pretreated with the Fenton's reagent, there was no pass-through toxicity to minnows in all of the pretreatment scenarios tested. However, toxicity to mysid shrimp was evident in all of the inhibition reactors pretreated with Fenton's reagent. As the AFFF concentrations increased, the LC_{50} levels decreased indicating increased levels of toxicity. In all of the test conditions, the feedstock was toxic to both minnows and mysid shrimp most possibly due to the presence of high ammonia concentrations.

TABLE 3-14. Summary of Toxicity Test Data for Inhibition Tests

Pretreatment Operation	Toxicity Bioassay Test Date	Sample Type	LC_{50}	
			Sheepshead Minnows	Mysid Shrimp
60 ppm AFFF + Defoamer 8710	Sept/30/97	Feedstock	3.5	8.1
		R.R. Mixed Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	72
		Inhibition B2	>100	66
		Inhibition B3	>100	65
60 ppm AFFF + Defoamer AF9020	Nov/3/97	Feedstock	19.7	12.5
		R.R. Mixed Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	50.5
		Inhibition B2	>100	50
		Inhibition B3	>100	45
120 ppm AFFF + Best Performing Defoamer (AF9020)	Dec/11/97	Feedstock	42	33
		R.R. Mixed Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control B1 Defoamer Only	>100	>100
		Control B2 Defoamer Only	>100	>100
		Inhibition C1 (AFFF+Def.)	>100	43.2
		Inhibition C2 (AFFF+Def.)	22.5	40.6
60 ppm AFFF + Fenton's Reagent	Nov/18/97	Feedstock	36.6	23.3
		R.R. Mixed Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	>100
		Inhibition B2	>100	93.9
		Inhibition B3	>100	75.2
120 ppm AFFF + Fenton's Reagent	Dec/2/97	Feedstock	30.6	39.2
		R.R. Mixed Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	40.2
		Inhibition B2	>100	63.9
		Inhibition B3	>100	66.0
480 ppm AFFF + Fenton's Reagent	Nov/25/97	Feedstock	13.8	9.7
		R.R. Mixed Liquor	>100	>100
		Control A1	>100	>100
		Control A2	>100	>100
		Control A3	>100	>100
		Inhibition B1	>100	>100
		Inhibition B2	>100	42.1
		Inhibition B3	>100	69.1

4.0 SUMMARY and CONCLUSIONS

The pretreatment results with defoamers demonstrated that effluent ammonia nitrogen concentrations for Defoamer # 8710 were higher (22-23 mg/L) than the effluent ammonia levels for the Defoamer AF 9020 (11.3 to 15.4 mg/L) indicating a better pretreatment and less nitrification inhibition for the latter defoamer (Figure 4-1). The nitrate production rates were in accordance with the ammonia removal rates, and were also demonstrated with excellent mass balances on the nitrogen species. In Phase I, at 60 ppm AFFF, the effluent ammonia levels were less than 1 mg/L indicating no nitrification inhibition. It should be noted that the aeration during the feed stage in Phase II was terminated to better simulate the VIP BNR operational conditions. The higher effluent ammonia levels in Phase II was most probably due to termination of aeration during the feed cycle of the inhibition reactors. In order to verify the effect of the additional aeration to nitrification, another inhibition test was conducted with 120 mg/L AFFF and the best performing defoamer (AF 9020). In this test the aeration stage of one of the triplicate inhibition and control reactors were extended for additional two hours. The effluent ammonia nitrogen levels were less than 0.1 mg/L for both controls and the inhibition reactors as exhibited in Figure 4-2. In all of the inhibition tests performed with the defoamers as pretreatment compounds, the COD removal rates decreased significantly in the inhibition reactors when compared to the control reactors with no defoamer or AFFF added. Even though the test conducted with the best performing defoamer under extended aeration operational mode showed some improvement in the COD removal rate, the reduction was only 50 percent when compared to the 90 percent reduction observed in the control reactor.

Fenton's reagent was used to pretreat AFFF at concentrations 60 ppm, 120 ppm, and 480 ppm. There were no nitrification inhibition at 60 ppm and 120 ppm AFFF wastewater pretreated with

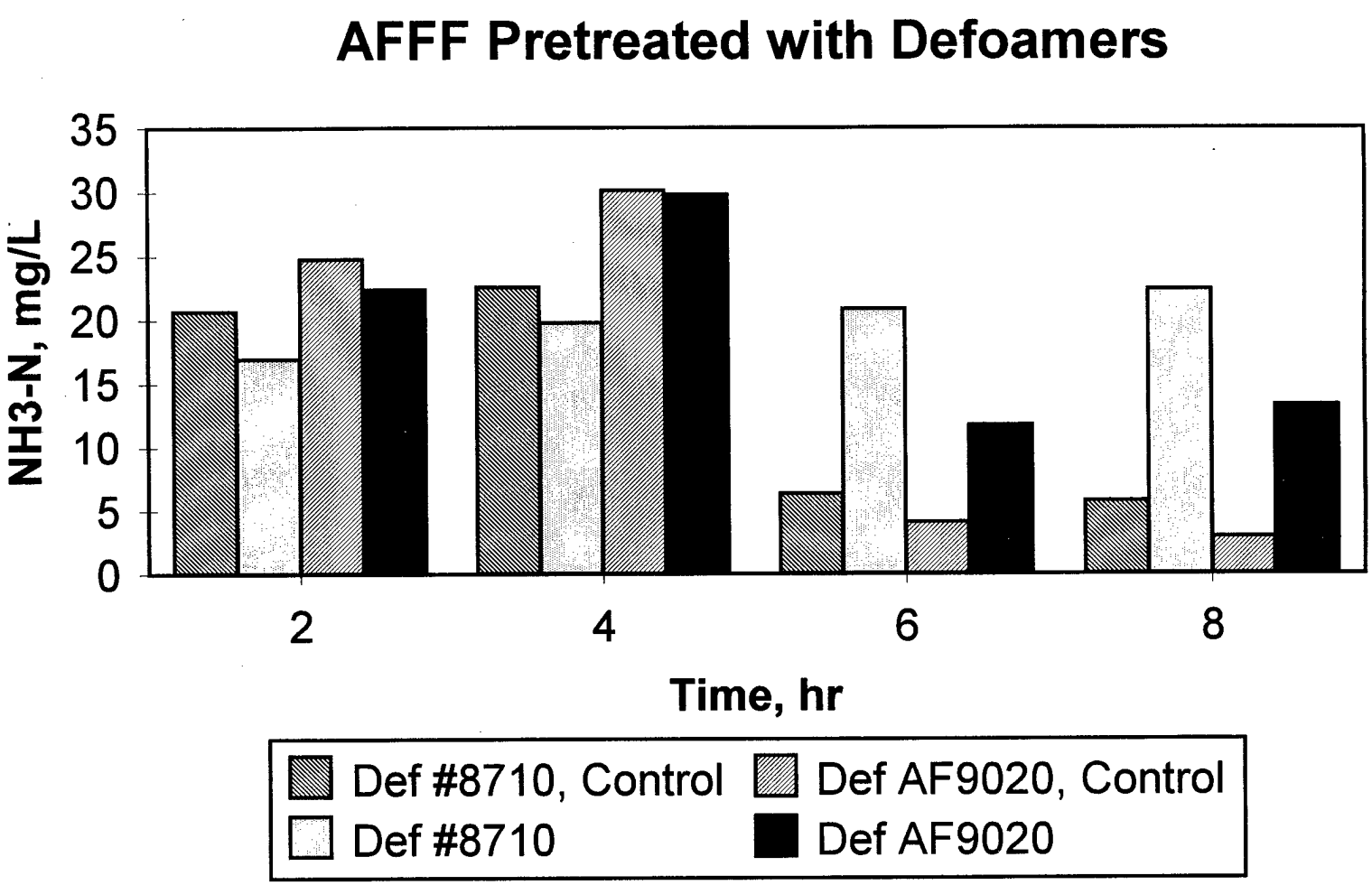


Figure 4-1. AFFF Pretreated with Defoamers (60 ppm AFFF)

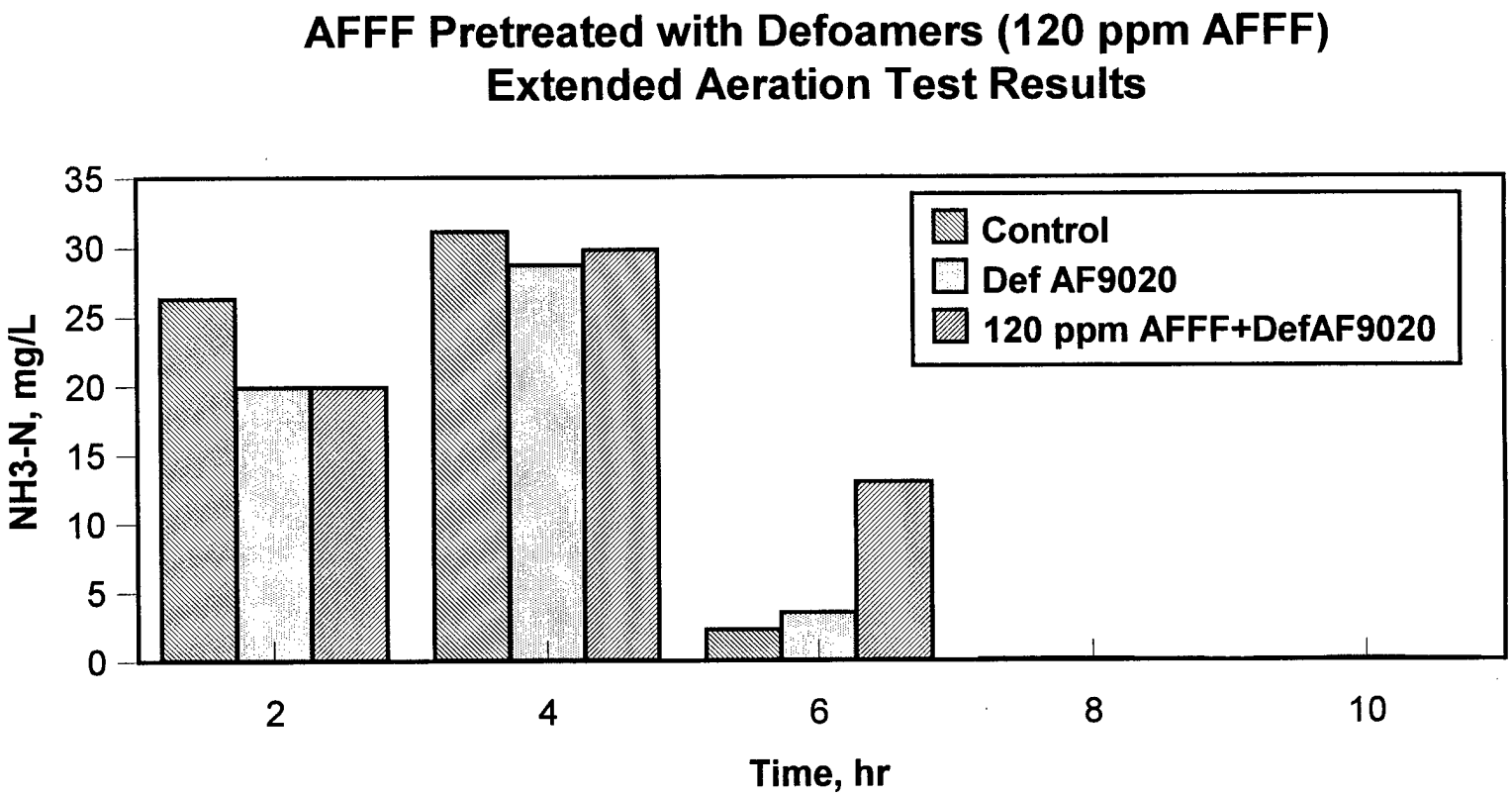


Figure 4-2. AFFF Pretreated with Defoamers under Extended Aeration Mode of Operation (120 ppm AFFF)

the Fenton's reagent as compared to the controls. Oxidation with Fenton's reagent was more effective than the defoamers used in pretreating AFFF. The nitrification inhibition potential decreased at concentrations greater than 60 ppm however, nitrification inhibition occurred at 480 ppm AFFF pretreated with Fenton's reagent. Figure 4-3 shows that the ammonia concentrations in the effluent were higher for 120 and 480 ppm AFFF without the extended aeration phase. However, the nitrification inhibition was significantly evident with extended aeration period at 480 ppm AFFF as shown in Figure 4-4.

The toxicity test results showed that, with the exception of one case, there was no pass-through toxicity to the sheepshead minnows in all both of the pretreatment options used in the inhibition tests. However, the effluent from the inhibition reactors were consistently toxic to mysid shrimp in all of the pretreatment options that included defoamers and Fenton's reagent. Toxicity was observed at 60 ppm AFFF concentration as well as 480 ppm AFFF concentration. The LC_{50} results did not exhibit any particular trends with increasing AFFF concentrations as well. In addition, the feedstock exhibited toxicity to both test organisms in all of the inhibition tests conducted due to the presence of high ammonia concentrations.

The analytical measurements for determination of butyl carbitol component of AFFF did not distinguish major prominent peaks in the chromatograms obtained from the ion chromatograph. The data was not sufficient enough to show a distinction between the control reactors and reactors containing AFFF.

The AFFF-laden wastewater pretreated with defoamers and Fenton's reagent did not show any nitrification inhibition at concentrations as high as 120 ppm AFFF. However, nitrification inhibition was evident at 480 ppm AFFF wastewater pretreated with Fenton's reagent.

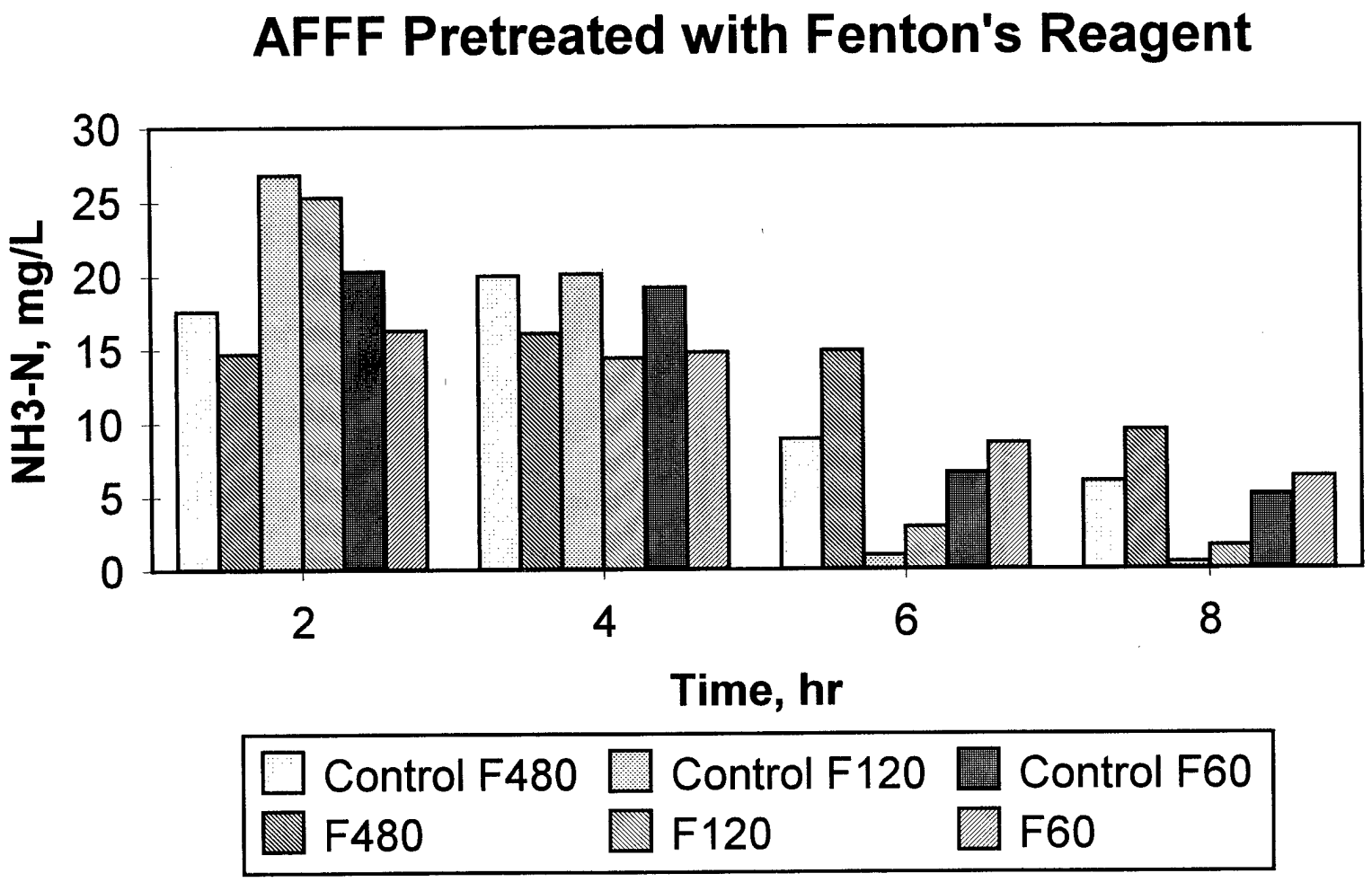


Figure 4-3. AFFF Pretreated with Fenton's Reagent

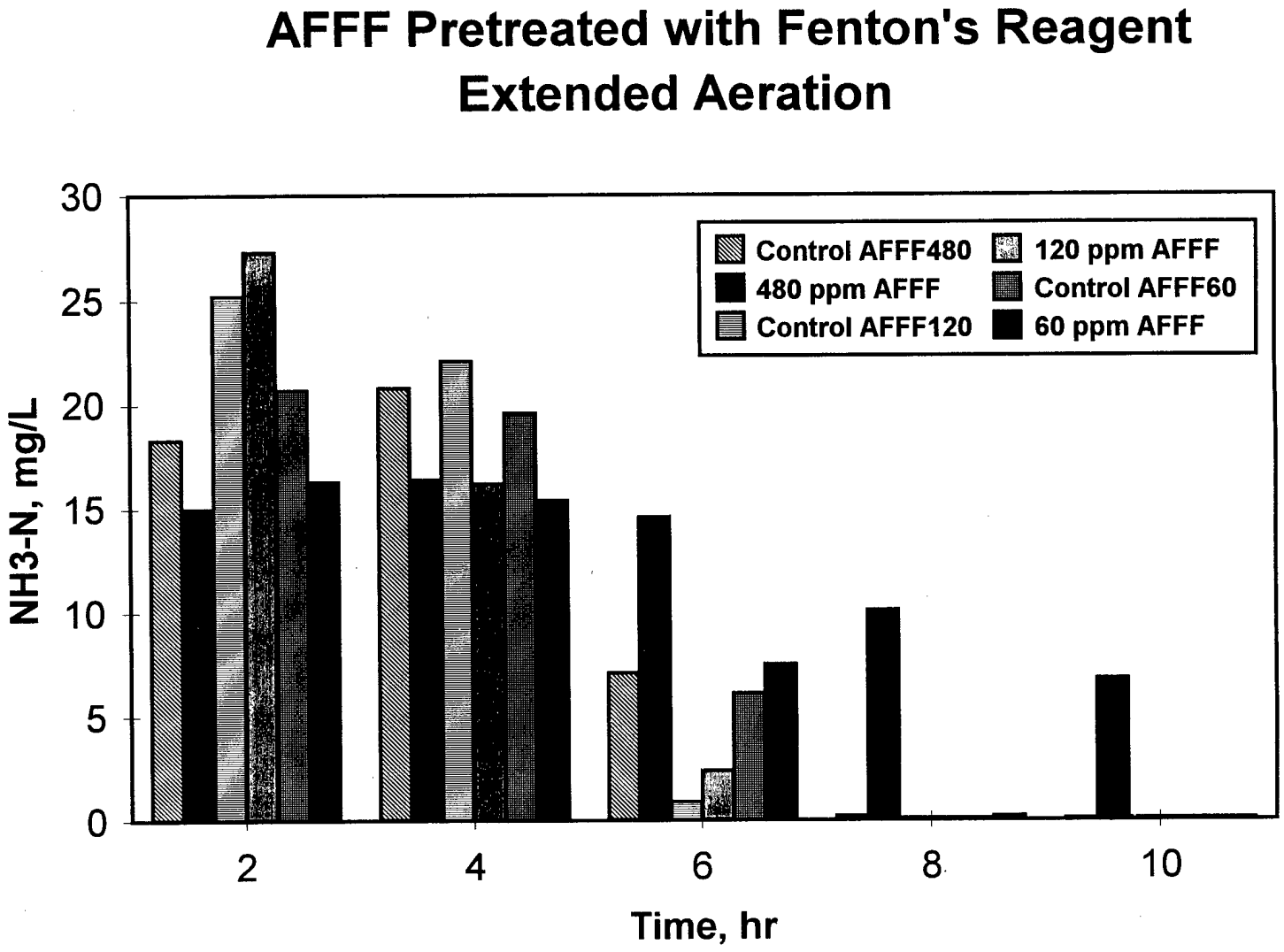


Figure 4-4. AFFF Pretreated with Fenton's Reagent (Extended Aeratiom Test Results)

In all of the pretreatment alternatives used, the inhibition reactor effluents exhibited pass-through toxicity to mysid shrimp at AFFF concentrations 60 ppm or greater, whereas the effluent was not toxic to the sheepshead minnows.

In summary, there is not an advantage to pretreating AFFF wastewater prior to discharge to a nitrifying plant because although pretreatment with defoamers or Fenton's reagent increases the inhibition concentration, it causes pass-through toxicity. The only time it may be used is if the nitrifying plant has mixing zone (i.e., acute toxicity limit of <1.0 Toxic Units). This would allow AFFF to be discharged at higher concentrations without causing pass-through toxicity.

References

American Public Health Association (1995). "Standard Methods for the Examination of Water and Wastewater." 19th Edition, Washington, DC.

Barbeni, M., Minero, C., Pelizzetti, E., Borgarello, E., and Serpone, N., (1987). "Chemical Degradation of Chlorophenols with Fenton's Reagent." *Chemosphere*, 16:2225-2237.

Bowers, A.R., Eckenfelder, W.W. Jr., Gaddipati, P., and Monsen, R.M., (1989). "Treatment of Toxic or Refractory Wastewater with Hydrogen Peroxide." *Water Science Technol,*. 21, p.477.

CH_2M Hill (1992). "Wastewater Effluent Pilot Study for the Advanced Fire Fighting Training Facility." Naval Facilities Engineering Command, Atlantic Division, Naval Contract N62470-91-R-6650.

CH_2M Hill (1995). "Wastewater Treatability Final Report for the Advanced Fire Fighting Training Facility." Naval Facilities Engineering Command, Atlantic Division, Navy Contract N62470-91-C-6650.

Chan, D. B., (1978). " Disposal of Wastewater Containing Aqueous Film Forming Foam." Technical Memorandum No. M-54-78-06, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, California.

Chan, D.B., and Bingham, P., (1988). 'AFFF-laden Wastewater Treatment Technology Initiation Decision Report (IDR)." Technical Memorandum No. TM-71-88-11, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, California.

EG&G (1978). "Toxicity of Selected Effluents from the U.S. Navy Firefighting School, Norfolk, VA to Embryos of Eastern Oysters." Technical Report by, Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia.

Engineering-Science Incorporated (1986). "Physical-Chemical Treatment from Navy Firefighting Schools." Naval Facilities Engineering Command, Atlantic Division, Contract No. N00025-74-C-0004, Norfolk, Virginia.

Erten-Unal, M., Paranjape, S., Schafran, G.C., and Williams, F.W., "Evaluation of the Effects of AFFF Inputs to VIP Biological Nutrient Removal Process and Pass-Through Toxicity-Phase IA",technical report, Naval Research Laboratory, NRL/MR/6180--98-8141, February 1998, 46pp.

Grace and Associates Inc., (1986). "Engineering Investigation of Impact of AFFF on Wastewater Treatment Performance at Naval Air Station, Memphis, Millington, Tennessee." U.S. Navy Contract N62467-86-C-0351, Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

LeFebvre, E.E. (1971). "Biodegradability and Toxicity of Light Water." Report No. EHL (K) 71-36, USAF Environmental Health Laboratory.

LeFebvre, E.E., and Inmand, R.C. (1975). "Biodegradability and Toxicity of ANSUL K74-100, Aqueous Film Forming Foam." Report No. EHL(K) 75-3, USAF Environmental Health Laboratory, Kelly AFB, Texas.

LeFebvre, E.E., and Inmand, R.C. (1974). "Biodegradability and Toxicity of Light water FC-206,, Aqueous Film Forming Foam." Report No. EHL(K) 74-26, USAF Environmental Health Laboratory, Kelly AFB, Texas.

LeFebvre, E.E., and Thomas, J.F. (1973). "Biodegradability and Toxicity of AER-O-Water 3% and 6% Aqueous Film Forming Foam." Report No. EHL(K) 73-22, USAF Environmental Health Laboratory, Kelly AFB, Texas.

Saam, R., and Rakowski, P. (1979). "Firefighting School Wastewater Study." Technical Memorandum No. 54-79-14, Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, California.

Saam, R., Rakowski, P, and Aydlett, G., (1979). "Treatability of Firefighting School Wastewaters: U.S. Navy Compliance with POTW Pretreatment Requirements." Proceedings of the 34th Purdue Industrial Waste Conference, West Lafayette, Indiana.

Thomas, J.F., and LeFebvre, E.E., (1973). "Biodegradability and Toxicity of FC-200 Aqueous Film Forming Foam." Report No. EHL(K) 74-3, USAF Environmental Health Laboratory, Kelly AFB, Texas.

United States Environmental Protection Agency (1979). "Methods of Chemical Analysis of Water and Wastes." Environmental Monitoring and Support Laboratory, EPA 600/4-79-020, Cincinnati, Ohio.

Union Carbide (1978). "Unox System Treatability Study Report, U.S. Navy Firefighting School." Naval Facilities Engineering Command, Atlantic Division, Norfolk, Virginia.

United States Environmental Protection Agency (1989). "Toxicity Reduction Evaluation Protocol for Municipal Wastewater Treatment Plants."

APPENDIX A

AFFF Butyl Carbitol Analysis

Dionex Chromatography DataBase

Sample	Alcohol standards	Record	100

Analytes and Concentrations	1. Ethanol, 2. 1-Propanol, 3. 2-methyl-2-propene-1-ol, 4. Cyclopentanol, 5. Phenylmethanol, 6. 1-Phenylethanol, 7. 3-Phenyl-1-propanol, 8. 2-Ethyl-1-hexanol, 9. 1-Decanol, 10. 1-Undecanol, 11. Dodecanol, 12. 1-Tridecanol, 13. 1-Tetradecanol

Columns	OmniPac PCX-500	Sample Vol	25 µL

No.	Mobile Phases & Postcolumn Reagents
1	90/10 Acetonitrile/Water
2	Water
PCR	0.3 M NaOH

Gradient Program

Time	%1	%2	%3	%4
.00	20	80		
.20	20	80		
5.00	95	5		
14.00	95	5		

Sample Dilution & Prep, Comments

Injection @ 0.1 minutes. Column equilibrated to initial conditions for at least 7 minutes before injection.

Flow Rates:	Mobile Phase	1 mL/min	Regen	mL/min	Reagent	1 mL/min

Detector and Settings

PAD (Au), E1 = 0.10V (720ms), E2 = 1.00V (120ms), E3=-0.80V (300ms)

Notes

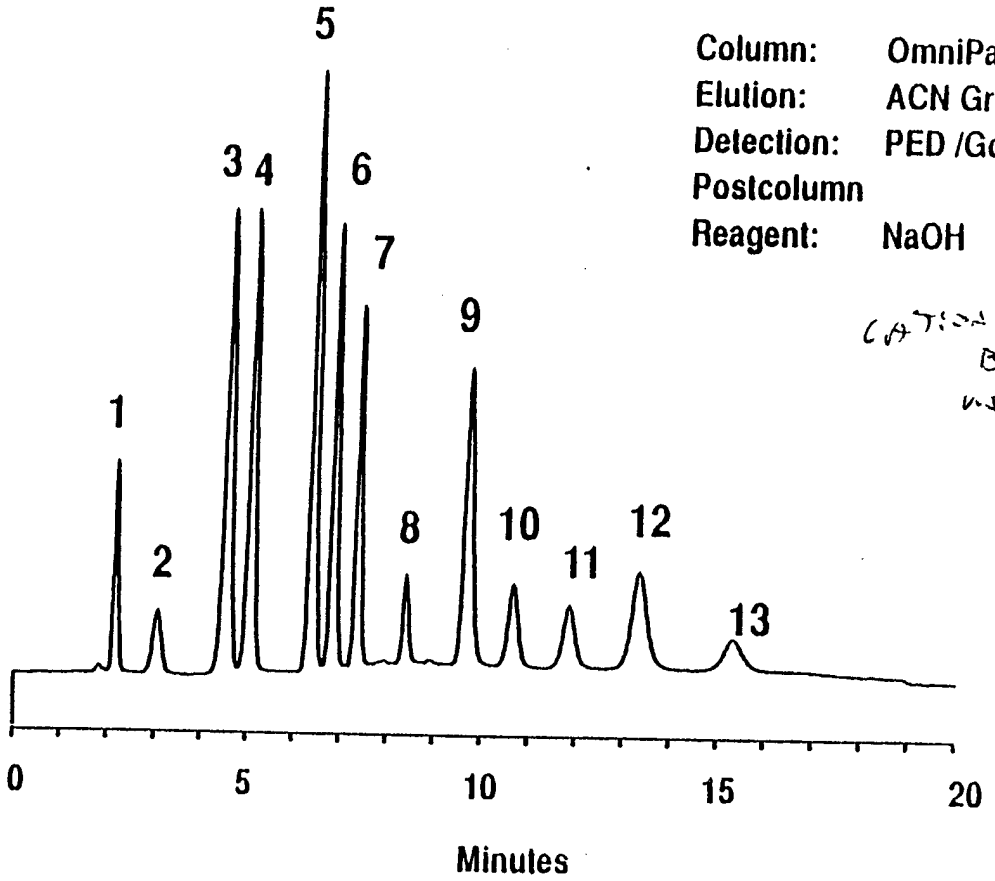
Optional columns for this application are OmniPac PAX-500 and IonPac NS1 10 µm.

Also: Anions = PAX500
not = NS1

Reference	Slide 5084-01

These results are intended as a starting point for methods development and are provided to show feasibility.

Monoalcohols with Pulsed Electrochemical Detection



Column: OmniPac PCX-500
Elution: ACN Gradient
Detection: PED /Gold Electrode
Postcolumn Reagent: NaOH

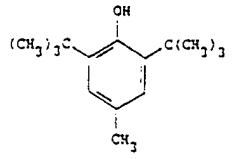
CATIONS & Butyl/carbinol use PCX

Peaks:

1. Ethanol
2. 1-Propanol
3. Methallyl alcohol
4. Cyclopentanol
5. Phenylmethanol
6. 1-Phenylethanol
7. 3-Phenyl-1-propanol
8. 2-Ethyl-1-hexanol
9. 1-Decanol
10. 1-Undecanol
11. 1-Dodecanol
12. 1-Tridecanol
13. 1-Tetradecanol

5084-01

Prepared from *p*-cresol and isobutylene: Stillson. U.S. pat. 2,428,745 (1947 to Gulf); McConnell, Davis. U.S. pat. 3,082,258 (1963 to Eastman Kodak). Inactivator of lipid-containing mammalian and bacterial viruses: Snipes *et al. Science* 188, 64 (1975).



Crystals. mp 70°. d_4^{20} 1.048. bp 265°. Flash pt (open cup): 260°F (127°C). Insol in water. Freely sol in toluene, sol in methanol, ethanol, isopropanol, methyl ethyl ketone, acetone, Cellosolve, petr ether, benzene, most other hydrocarbon solvents. Soly in liquid petrolatum (white oil): 0.5% w/w. More sol in food oils and fats than butylated hydroxyanisole. Good soly in linseed oil. LD_{50} orally in mice: 1040 mg/kg, *J. Am. Pharm. Assoc.* 38, 366 (1949).

USE: Antioxidant for food, animal feed, petrol products, synthetic rubbers, plastics, animal and vegetable oils, soaps. Antiskinning agent in paints and inks.

1522. *n*-Butylbenzene. 1-Phenylbutane. $C_{10}H_{14}$; mol wt 134.21. C 89.49%, H 10.51%. $C_6H_5(CH_2)_3CH_3$. Prepn: Radziszewski, *Ber.* 9, 261 (1876); Balbiano, *Ber.* 10, 296 (1877); Read, Foster, *J. Am. Chem. Soc.* 48, 1606 (1926).

Liquid. mp −88.5°. d_4^{20} 0.8604. bp_{760} 183.1°; bp_{400} 159.2°; bp_{200} 136.9°; bp_{100} 116.2°; bp_{60} 102.6°; bp_{40} 92.4°; bp_{20} 76.3°; bp_{10} 62.0°; bp_5 48.8°; $bp_{1.0}$ 22.7°. n_D^{20} 1.49040. Flash pt, open cup: 160° F (71° C). Insol in water; miscible with alcohol, ether, benzene.

1523. *sec*-Butylbenzene. *(1-Methylpropyl)benzene;* 2-phenylbutane. $C_{10}H_{14}$; mol wt 134.21. C 89.49%, H 10.51%. $C_6H_5CH(CH_3)CH_2CH_3$. Prepd from benzene and *n*-butyl chloride in presence of $AlCl_3$: Schramm, *Monatsh.* 9, 621 (1888); by the action of sodium on γ-chloro-*sec*-butylbenzene: Braun *et al., Ber.* 46, 1277 (1913); with other products by heating *n*- or *sec*-butyl alcohol with 80% H_2SO_4: Meyer, Bernhauer, *Monatsh.* 53, 727 (1929).

Liquid. mp −82.7°. d_4^{20} 0.8608. bp_{760} 173.5°; bp_{400} 150.3°; bp_{200} 128.8°; bp_{100} 109.5°; bp_{60} 96.0°; bp_{40} 86.2°; bp_{20} 70.6°; bp_{10} 57.0°; bp_5 44.2°; $bp_{1.0}$ 18.6°. n_D^{20} 1.48980. Flash pt, closed cup: 126° F (52° C). Insol in water; misc with alcohol, ether, benzene.

d-Form. $[\alpha]_D^{25}$ +26.6°: Bonner, Greenlee, *J. Am. Chem. Soc.* 81, 3336 (1959).

l-Form. $[\alpha]_D^{25}$ −27.3°.

USE: Solvent; in organic syntheses.

1524. *tert*-Butylbenzene. *(1,1-Dimethylethyl)benzene;* 2-methyl-2-phenylpropane; trimethylphenylmethane; pseudobutylbenzene. $C_{10}H_{14}$; mol wt 134.21. C 89.49%, H 10.51%. $C_6H_5C(CH_3)_3$. Prepn: Konowalow, *Bull. Soc. Chim.* [3] 16, 865 (1896); Shoesmith, Mackie, *J. Chem. Soc.* 1928, 2336; Meyer, Bernhauer, *Monatsh.* 53, 727 (1929); Wilt, Abegg, *J. Org. Chem.* 33, 923 (1968). *See also* Groose, Ipatieff, *J. Am. Chem. Soc.* 57, 2415 (1935); Ipatieff, Pines, *ibid.* 58, 1056 (1936).

Liquid. mp −58.1°. d_4^{20} 0.8669. bp_{760} 168.5°; bp_{400} 145.8°; bp_{200} 123.7°, bp_{100} 103.8°; bp_{60} 90.6°; bp_{40} 80.8°; bp_{20} 65.6°; bp_{10} 51.7°; bp_5 39.0°; $bp_{1.0}$ 13.0°. n_D^{20} 1.49235. Flash pt, open cup: 140°F (60°C). Insol in water; misc with alcohol, ether, benzene.

1525. *n*-Butyl Benzoate. *Benzoic acid butyl ester.* $C_{11}H_{14}O_2$; mol wt 178.22. C 74.13%, H 7.92%, O 17.95%. $C_6H_5COO(CH_2)_3CH_3$. Prepn: Newman, Fones, *J. Am. Chem. Soc.* 69, 1046 (1947); Justoni, Brit. pat. 719,891 (1954 to Vismara).

Thick, oily liquid. d 1.00. mp −22°. bp 250°. Practically insoluble in water; sol in alcohol or ether. LD_{50} orally in rats: 5.14 g/kg, Smyth *et al., Arch. Ind. Hyg. Occup. Med.* 10, 61 (1954).

1526. *n*-Butyl Bromide. *1-Bromobutane.* C_4H_9Br; mol wt 137.03. C 35.06%, H 6.62%, Br 58.32%. $CH_3(CH_2)_3Br$. Prepd from *n*-butyl alc and a hydrobromic-sulfuric acid mixture: Kamm, Marvel, *Org. Syn.* vol. I, 5 (1921); Skau, McCullough, *J. Am. Chem. Soc.* 57, 2440 (1935).

Colorless liquid. d_4^{25} 1.2686. bp_{760} 101.3° (mp −112°). n_D^{20} 1.4398. Insol in water; sol in alcohol, ether.

1527. *sec*-Butyl Bromide. *2-Bromobutane;* methylethylbromomethane. C_4H_9Br; mol wt 137.03. C 35.06%, H 6.62%, Br 58.32%. $CH_3CH_2CHBrCH_3$. Prepn: Levene, Marker, *J. Biol. Chem.* 91, 405 (1931); Kenyon *et al., J. Chem. Soc.* 1935, 1080; Skau, McCullough, *J. Am. Chem. Soc.* 57, 2440 (1935); Colson *et al., J. Chem. Soc.* 1965, 2364. Prepn of optically pure isomers: Goodwin, Hudson, *J. Chem. Soc. (B)* 1968, 1333.

dl-Form. colorless liquid, pleasant odor. d_4^{25} 1.2530. bp 91.2° (mp −112°). n_D^{25} 1.4344. Insol in water. Freely sol in alcohol, ether.

d-Form. n_D^{20} 1.4359-1.4362. α_D^{20} −42.64°.

l-Form. n_D^{20} 1.4368. α_D^{20} −43.7°.

Caution: Narcotic in high concns.

1528. *tert*-Butyl Bromide. *2-Bromo-2-methylpropane;* 2-bromoisobutane; trimethylbromomethane. C_4H_9Br; mol wt 137.03. C 35.06%, H 6.62%, Br 58.32%. $(CH_3)_3CBr$. Prepn: Brunel, *J. Am. Chem. Soc.* 39, 1978 (1917); Bryce-Smith, Howlett, *J. Chem. Soc.* 1951, 1141; Coe *et al., ibid.* 1954, 2281.

Colorless liquid. d_4^{25} 1.2125. bp 73.3°. fp −16.3°. At 210° changes to isobutyl bromide. n_D^{25} 1.4249. Insol in water; miscible with organic solvents.

1529. *n*-Butyl *n*-Butyrate. *Butanoic acid butyl ester; butyric acid butyl ester.* $C_8H_{16}O_2$; mol wt 144.21. C 66.63%, H 11.18%, O 22.19%. $CH_3(CH_2)_2COO(CH_2)_3CH_3$. Prepn from butyl alcohol: Robertson, *Org. Syn.* coll. vol. I, 138 (1941); Horton, U.S. pat. 2,522,676 (1950 to Socony-Vacuum Oil).

Liquid. bp 165°. d_4^{20} 0.8692. n_D^{20} 1.4064. Practically insol in water; miscible with alcohol, ether.

1530. Butyl Carbitol®. *2-(2-Butoxyethoxy)ethanol;* diethylene glycol monobutyl ether. $C_8H_{18}O_3$; mol wt 162.22. C 59.23%, H 11.18%, O 29.59%. $HOCH_2CH_2OCH_2CH_2OC_4H_9$. Prepn: Riemschneider, Gross, *Monatsh.* 90, 783 (1959). Purification: Miller, Yonan, *J. Am. Chem. Soc.* 79, 5931 (1957); Ridley, Ridley, Brit. pat. 795,866 (1958 to Esso).

Practically odorless liquid. bp 230.4°. mp −68.1°. d_{25}^{25} 0.9536. n_D^{17} 1.4258. Miscible in water, oils. Miscibility in other organic solvents: Jackson, Drury, *Ind. Eng. Chem.* 51, 1491 (1959). Flash pt 110°. LD_{50} orally in rats, guinea pigs: 6.56, 2.00 g/kg, Smyth *et al., J. Ind. Hyg. Toxicol.* 23, 259 (1941).

1531. *n*-Butyl Carbonate. *Carbonic acid dibutyl ester;* dibutyl carbonate. $C_9H_{18}O_3$; mol wt 174.23. C 62.04%, H 10.41%, O 27.55%. $(C_4H_9O)_2CO$. Prepn from ethyl carbonate, butyl alcohol and ethylmagnesium bromide: Frank *et al., J. Am. Chem. Soc.* 66, 1509 (1944); from butyl alcohol and CO in the presence of Pd and $CuCl_2$: Mador, Blackham, U.S. pat. 3,114,762 (1963 to National Distillers).

Liquid. bp 206.6°. d_4^{20} 0.9251, d_4^{15} 0.9388. n_D^{20} 1.4117. Practically insol in water. Miscible with ethanol, benzene, chloroform, acetone, ether and other organic solvents, *see:* Jackson, Drury, *Ind. Eng. Chem.* 51, 1491 (1959).

1532. Butyl Cellosolve®. *2-Butoxyethanol;* ethylene glycol monobutyl ether. $C_6H_{14}O_2$; mol wt 118.17. C 60.98%, H 11.94%, O 27.08%. $HOCH_2CH_2OC_4H_9$. Prepn from butyl alcohol and ethylene carbonate or 2-chloroethanol, or from ethylene glycol and butyl bromide: Carlson, U.S. pat. 2,448,767 (1948 to Mellon Inst. Ind. Res.); Klamann, Bertsch, *Ber.* 88, 201 (1955); Riemschneider, Gross, *Monatsh.* 90, 783 (1959). Toxicity: Carpenter *et al., Arch. Ind. Health* 14, 114 (1956).

Liquid. bp 171-172°. d_4^{20} 0.9012, d_{20}^{20} 0.9019. n_D^{20} 1.4196. Flash pt, closed cup: 141°F (60°C). Soluble in 20 parts water; sol in most organic solvents, in mineral oil. LD_{50} orally in rats: 1.48 g/kg, H. F. Smyth *et al., J. Ind. Hyg. Toxicol.* 23, 259 (1941).

USE: Solvent for nitrocellulose, resins, grease, oil, albumin; dry cleaning. *Caution:* Toxic symptoms similar to those for Methyl Cellosolve.

1533. *n*-Butyl Chl
binyl chloride; butyl
51.90%, H 9.80%, Cl
from *n*-butyl alcohol
$ZnCl_2$: Whaley, Cope
(1938); *Org. Syn.* coll.
Liquid. *Highly flar*
0.88098. One gallon
bp_{760} 78.5°. n_D^{20} 1.402
moment: 1.95. Pract
Misc with alcohol, eth
F. Smyth *et al., Arch.*
USE: As butylating
manuf of butyl cellulo
THERAP CAT (VET): A

1534. *sec*-Butyl Cl
methylpropane. C_4H_9
Cl 38.30%. CH_3CH_2C
hol, hydrochloric acid
Chem. Soc. 46, 756 (1
coll. vol. I, 143 (194
Coulson *et al., J. Chen*
pure isomers: Goodv
1333.
dl-Form: liquid; pl
68°. n_D^{20} 1.3960; n_D^{15} 1.
water at 25°; misc wit
20.0 ml/kg, H. F. Sm
470 (1969).
d-Form: n_D^{20} 1.396
l-Form: n_D^{20} 1.3968
Caution: Mild irrita

1535. *tert*-Butyl C
2-chloroisobutane; tri
wt 92.57. C 51.90%
Prepd by shaking *ter*
distilling: Norris, Ol
from *tert*-butyl alcoh
Soc. 1953, 1920.
Liquid. d_4^{15} 0.847.
bp_{400} 32.6°; bp_{200} +1
−19.0°. Sparingly so
ether. Boiling with w

1536. *tert*-Butyl Cl
methyl ester; t-butyl
butyl ester, $C_6H_{11}ClO$
Cl 23.54%, O 21.25%.
ing monochloroacetic
presence of sulfuric ac
75, 4995 (1953); from
ride and dimethylanili
Liquid. bp 155° (d
1.4204-1.4210; n_D^{20} 1.4
alcohol and chloroace
USE: In the glycidic

1537. Butyl Citrate
ylic acid tributyl ester;
trate; tributyl citrate.
H 8.95%, O 31.07%.
(1950). Synthesis fr
Benedict, *Chemistry* 4

Colorless or pale ye
about 233°. mp −20°
Insol in water; miscib
USE: Plasticizer and
polishes, inks and sim

1538. α-Butylene
H_8Br_2; mol wt 215.9
$CH_3CH_2CHBrCH_2Br$

APPENDIX B

********** AUTOMATIC CALIBRATION UPDATE **********

Data File : c:\peaknet\data\afff0008.DXD	Report Date: 11/2/97 9:07:01 PM
Sample Name: Autocal 2-1ppm	Collected : 11/2/97 8:38:40 PM
Inject # : 8	Vial # :
Method File: c:\peaknet\method\afff.met	Last Update: 11/2/97 8:38:32 PM
System Name: DX-500	Detector : ED40
Cal. Level : 2	Analyst :

********** COMPONENTS FOUND IN THIS RUN **********

COMP NUM	COMPONENT NAME	OLD RET.TIME	MEASURED RET.TIME	NEW RET.TIME	OLD RESPONSE	MEASURED RESPONSE	NEW RESPONSE

Data File : c:\peaknet\data\afff0008.DXD	Report Date: 11/2/97 9:07:01 PM
Sample Name: Autocal 2-1ppm	Collected : 11/2/97 8:38:40 PM
Inject # : 8	Vial # :
Method File: c:\peaknet\method\afff.met	Calibrated : 11/2/97 9:07:01 PM
System Name: DX-500	Detector : ED40
Column Type:	Operator :
Data Points: 1200	Rate : 1.00 Hz
Module Name: ID:24 0a 85	Moduleware : 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

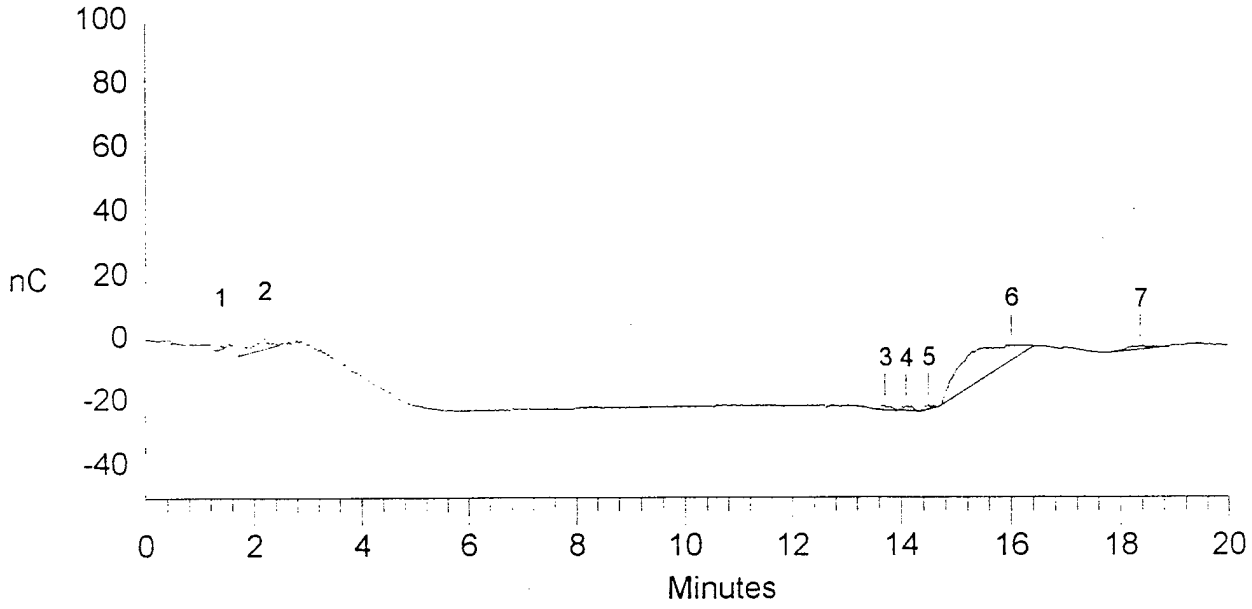
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.37		0.000	11804	56265	1	
2	2.18		0.000	33188	782834	1	
3	13.70		0.000	13711	185872	1	
4	14.08		0.000	14174	185381	1	
5	14.48		0.000	13376	127915	1	
6	16.00		0.000	47029	6262576	1	
7	18.35		0.000	9733	351092	1	
		Totals	0.000	143015	7951935		

File: afff0008.DXD Sample Autocal 2-1ppm



********** AUTOMATIC CALIBRATION UPDATE **********

Data File : c:\peaknet\data\afff0009.DXD	Report Date: 11/2/97 9:35:30 PM
Sample Name: Autocal 3-10ppm	Collected : 11/2/97 9:07:09 PM
Inject # : 9	Vial # :
Method File: c:\peaknet\method\afff.met	Last Update: 11/2/97 9:07:01 PM
System Name: DX-500	Detector : ED40
Cal. Level : 3	Analyst :

********** COMPONENTS FOUND IN THIS RUN **********

COMP NUM	COMPONENT NAME	OLD RET.TIME	MEASURED RET.TIME	NEW RET.TIME	OLD RESPONSE	MEASURED RESPONSE	NEW RESPONSE

Data File : c:\peaknet\data\afff0009.DXD	Report Date: 11/2/97 9:35:30 PM
Sample Name: Autocal 3-10ppm	Collected : 11/2/97 9:07:09 PM
Inject # : 9	Vial # :
Method File: c:\peaknet\method\afff.met	Calibrated : 11/2/97 9:35:30 PM
System Name: DX-500	Detector : ED40
Column Type:	Operator :
Data Points: 1200	Rate : 1.00 Hz
Module Name: ID:24 0a 85	Moduleware : 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

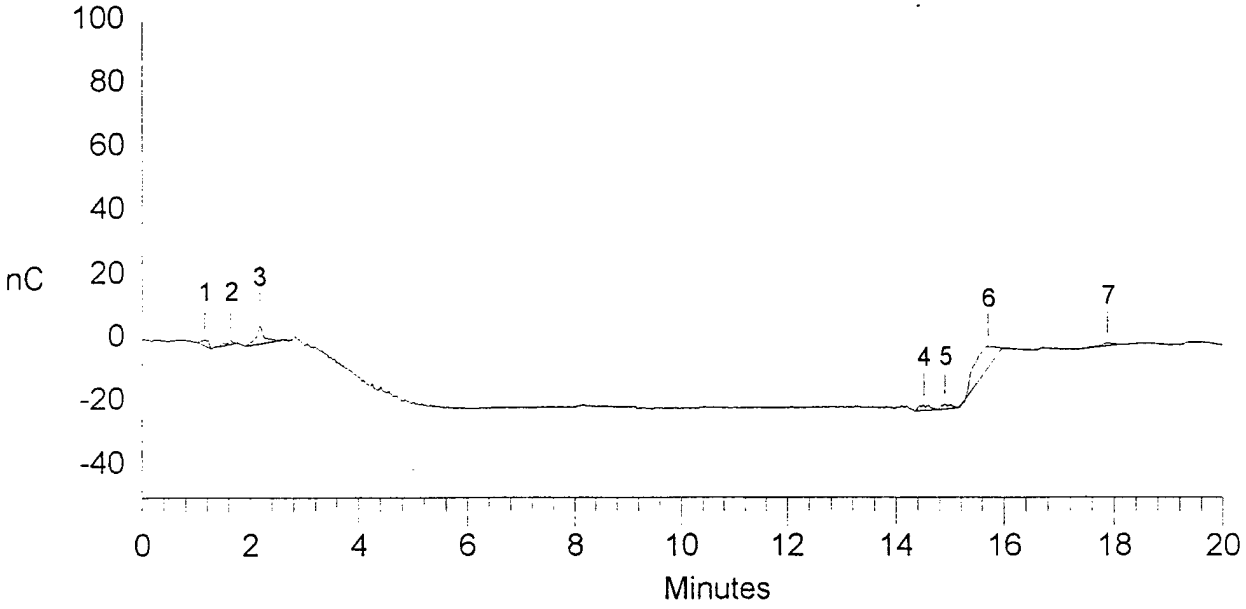
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.15		0.000	16763	174443	1	
2	1.63		0.000	12772	109527	1	
3	2.17		0.000	57222	608242	1	
4	14.50		0.000	17590	241420	1	
5	14.90		0.000	15712	186309	1	
6	15.70		0.000	66779	2046738	1	
7	17.87		0.000	8401	146694	1	
		Totals	0.000	195240	3513373		

File: afff0009.DXD Sample Autocal 3-10ppm



********** AUTOMATIC CALIBRATION UPDATE **********

Data File : c:\peaknet\data\afff0010.DXD	Report Date: 11/2/97 10:04:00 PM
Sample Name: Autocal 4-50ppm	Collected : 11/2/97 9:35:38 PM
Inject # : 10	Vial # :
Method File: c:\peaknet\method\afff.met	Last Update: 11/2/97 9:35:30 PM
System Name: DX-500	Detector : ED40
Cal. Level : 4	Analyst :

********** COMPONENTS FOUND IN THIS RUN **********

COMP NUM	COMPONENT NAME	OLD RET.TIME	MEASURED RET.TIME	NEW RET.TIME	OLD RESPONSE	MEASURED RESPONSE	NEW RESPONSE

Data File : c:\peaknet\data\afff0010.DXD	Report Date: 11/2/97 10:04:00 PM
Sample Name: Autocal 4-50ppm	Collected : 11/2/97 9:35:38 PM
Inject # : 10	Vial # :
Method File: c:\peaknet\method\afff.met	Calibrated : 11/2/97 10:04:00 PM
System Name: DX-500	Detector : ED40
Column Type:	Operator :
Data Points: 1200	Rate : 1.00 Hz
Module Name: ID:24 0a 85	Moduleware : 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

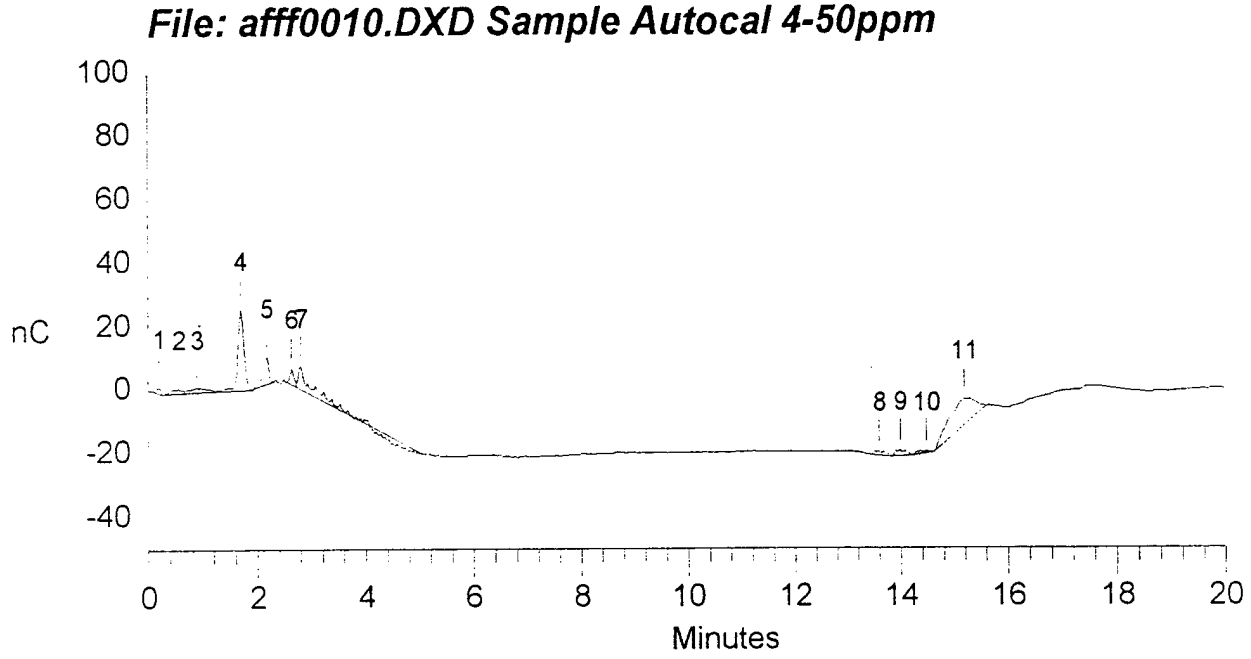
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	0.20		0.000	17700	101128	1	
2	0.55		0.000	15933	209209	2	
3	0.88		0.000	13966	318774	2	
4	1.68		0.000	253910	2050260	2	
5	2.17		0.000	86432	639595	1	
6	2.63		0.000	52031	252956	2	
7	2.80		0.000	70379	560109	2	
8	13.58		0.000	13995	192785	1	
9	13.98		0.000	19065	245079	1	
10	14.47		0.000	7367	100201	1	
11	15.18		0.000	82451	2829753	1	

Totals	0.000	633229	7499848



Data File	: c:\peaknet\data\afff0011.DXD	Report Date	: 11/2/97 10:32:28 PM
Sample Name	: Feedstock	Collected	: 11/2/97 10:04:08 PM
Inject #	: 11	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

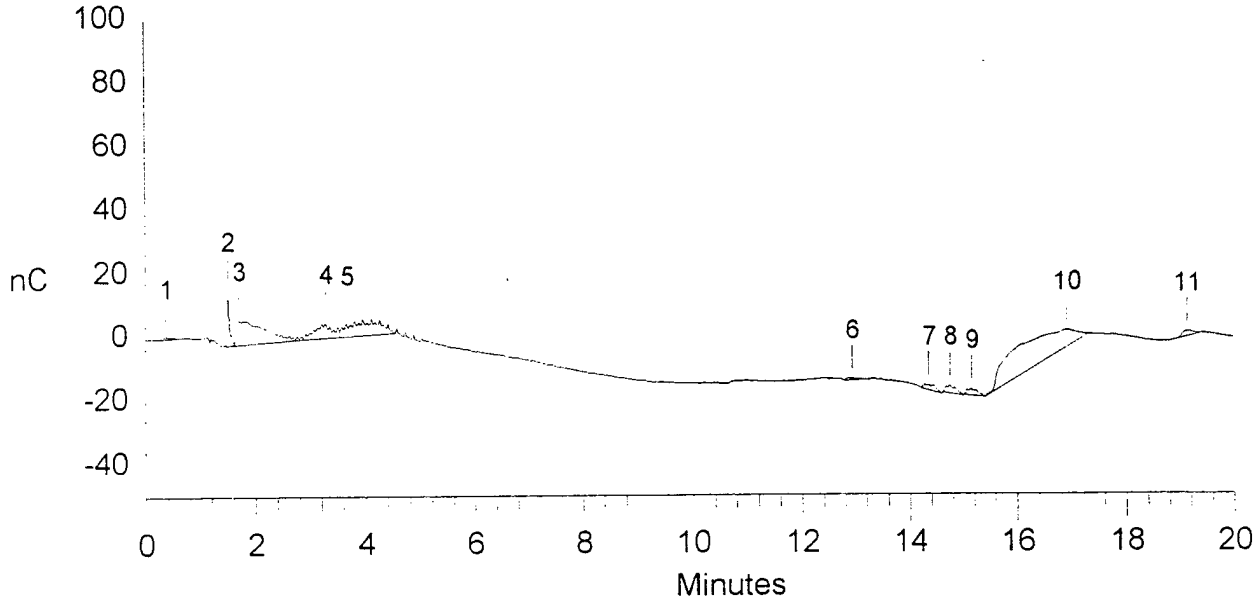
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	0.37		0.000	6079	73315	1	
2	1.50		0.000	174280	503133	2	
3	1.70		0.000	78894	2767642	2	
4	3.28		0.000	47648	977080	2	
5	3.67		0.000	38382	1749473	2	
6	12.92		0.000	5671	71319	1	
7	14.35		0.000	16647	234728	1	
8	14.75		0.000	25643	309572	1	
9	15.15		0.000	20530	257484	1	
10	16.90		0.000	54468	6735289	1	
11	19.12		0.000	17625	226412	1	
		Totals	0.000	485866	13905446		

File: afff0011.DXD Sample Feedstock



Data File	: c:\peaknet\data\afff0012.DXD	Report Date	: 11/2/97 11:00:54 PM
Sample Name	: R.R.Supernatant	Collected	: 11/2/97 10:32:36 PM
Inject #	: 12	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

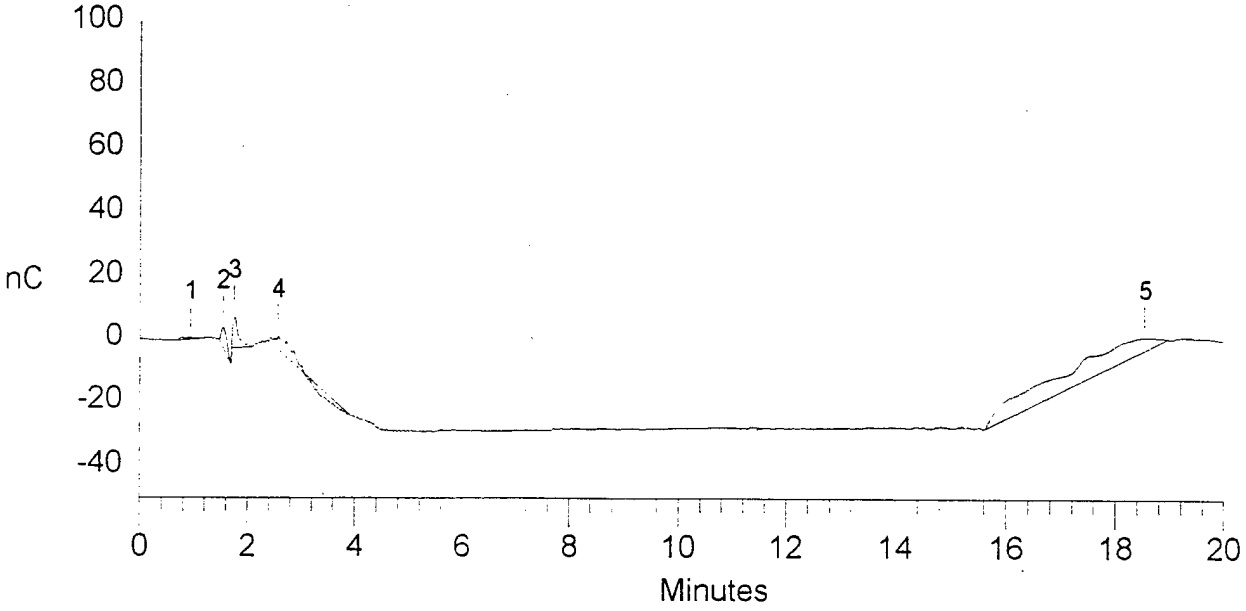
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	0.93		0.000	5135	110929	1	
2	1.53		0.000	65168	497555	1	
3	1.75		0.000	97372	701056	1	
4	2.57		0.000	42968	447030	1	
5	18.52		0.000	42378	9958336	1	
		Totals	0.000	253021	11714906		

File: afff0012.DXD Sample R.R.Supernatant



Data File	: c:\peaknet\data\afff0013.DXD	Report Date	: 11/2/97 11:29:19 PM
Sample Name	: A1 end of feed--control	Collected	: 11/2/97 11:01:02 PM
Inject #	: 13	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

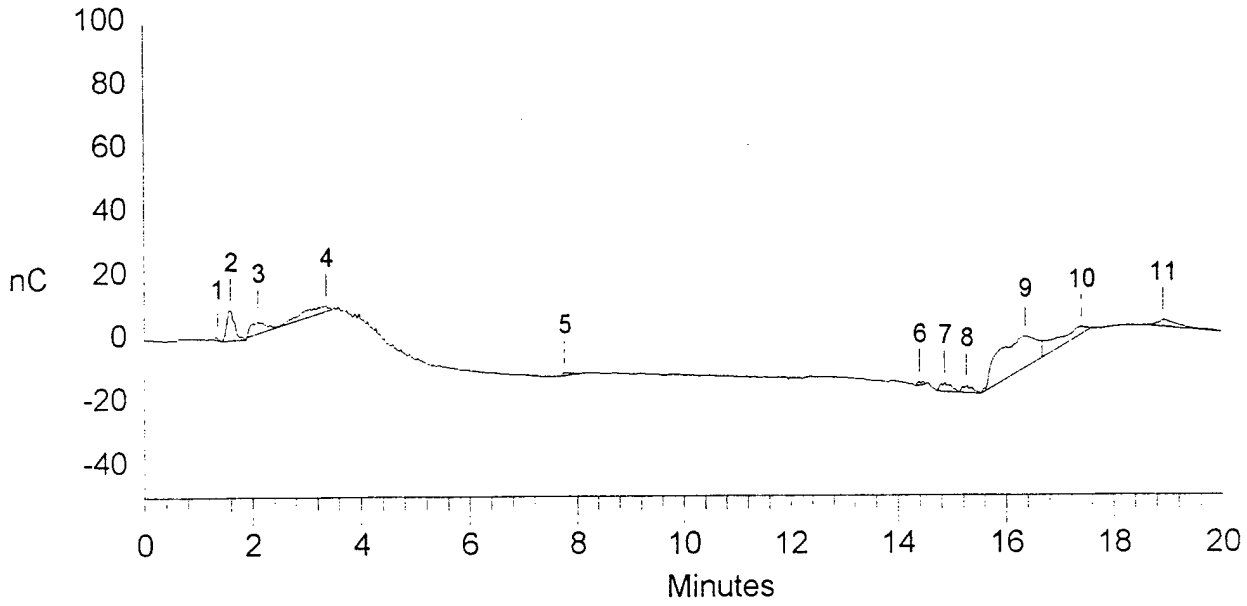
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.35		0.000	8247	60027	1	
2	1.60		0.000	93738	972378	1	
3	2.10		0.000	36379	737607	2	
4	3.37		0.000	17276	868206	2	
5	7.77		0.000	9051	101992	1	
6	14.40		0.000	10905	68482	1	
7	14.87		0.000	26453	356033	2	
8	15.27		0.000	20568	258871	2	
9	16.35		0.000	95874	5219791	2	
10	17.40		0.000	22380	1386225	2	
11	18.92		0.000	19295	519742	1	
		Totals	0.000	360166	10549353		

File: afff0013.DXD Sample A1 end of feed--control



Data File	: c:\peaknet\data\afff0014.DXD	Report Date	: 11/2/97 11:57:47 PM
Sample Name	: A2 end of feed--control	Collected	: 11/2/97 11:29:28 PM
Inject #	: 14	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

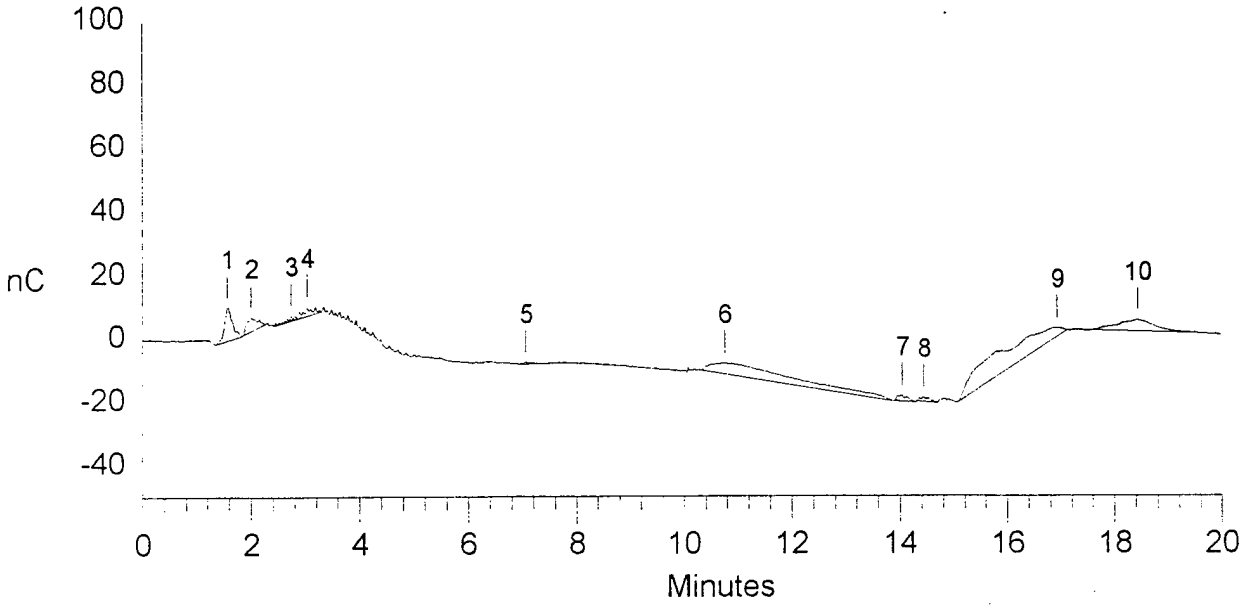
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.57		0.000	103565	1078567	1	
2	2.00		0.000	43305	605094	1	
3	2.73		0.000	17326	140831	2	
4	3.03		0.000	28232	338452	2	
5	7.05		0.000	4724	54002	1	
6	10.75		0.000	33995	4383015	1	
7	14.03		0.000	19348	236017	1	
8	14.43		0.000	15740	189493	1	
9	16.92		0.000	30076	6191445	1	
10	18.42		0.000	34818	1652544	1	
		Totals	0.000	331131	14869459		

File: afff0014.DXD Sample A2 end of feed--control



Data File	: c:\peaknet\data\afff0015.DXD	Report Date	: 11/3/97 12:26:15 AM
Sample Name	: A3 end of feed--control	Collected	: 11/2/97 11:57:56 PM
Inject #	: 15	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

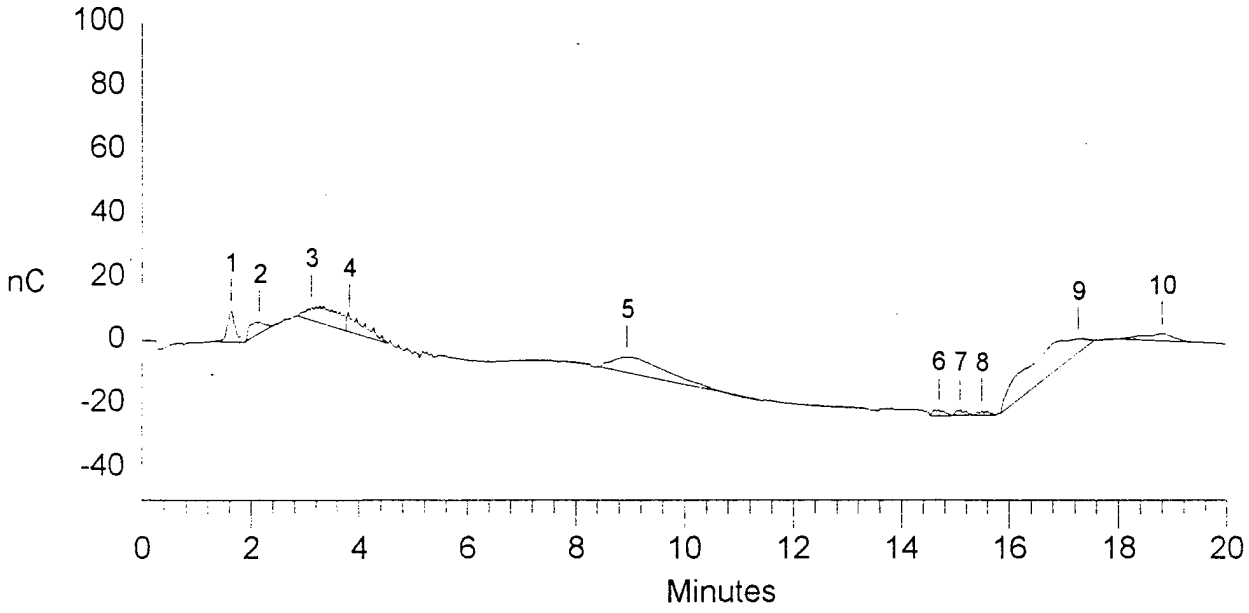
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.62		0.000	97035	1022349	1	
2	2.15		0.000	34952	779163	1	
3	3.12		0.000	42930	2157887	2	
4	3.82		0.000	48690	1283012	2	
5	8.93		0.000	48685	3596865	1	
6	14.68		0.000	17855	246147	2	
7	15.08		0.000	15788	193096	2	
8	15.48		0.000	11909	157173	1	
9	17.25		0.000	44837	6514876	1	
10	18.78		0.000	23020	900380	1	
		Totals	0.000	385700	16850947		

File: afff0015.DXD Sample A3 end of feed--control



Schedule: \peaknet\schedule\afff11_2.sch
Release 4.30 Page 2 of 2 11/3/97 12:26:15 AM

Data File	: c:\peaknet\data\afff0016.DXD	Report Date	: 11/3/97 12:54:44 AM
Sample Name	: B1 end of feed--60ppm	Collected	: 11/3/97 12:26:24 AM
Inject #	: 16	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

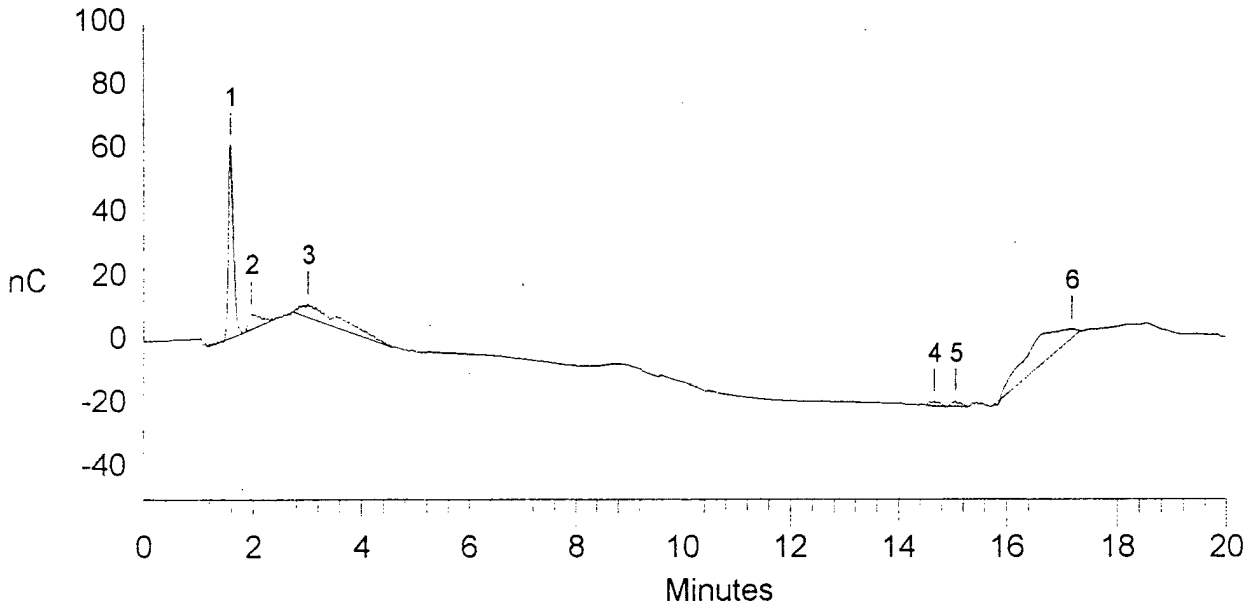
Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.58		0.000	599958	3884904	1	
2	1.97		0.000	47856	726511	1	
3	3.02		0.000	41021	2497687	1	
4	14.67		0.000	14640	189454	1	
5	15.07		0.000	16736	196379	1	
6	17.18		0.000	27874	4714611	1	
		Totals	0.000	748084	12209545		


File: afff0016.DXD Sample B1 end of feed--60ppm
100
80
60
40
20
0
-20
-40
nC
1
2
3
4 5
6
0
2
4
6
8
10
12
14
16
18
20
Minutes

Data File	: c:\peaknet\data\afff0017.DXD	Report Date	: 11/3/97 1:23:12 AM
Sample Name	: B2 end of feed--60ppm	Collected	: 11/3/97 12:54:52 AM
Inject #	: 17	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

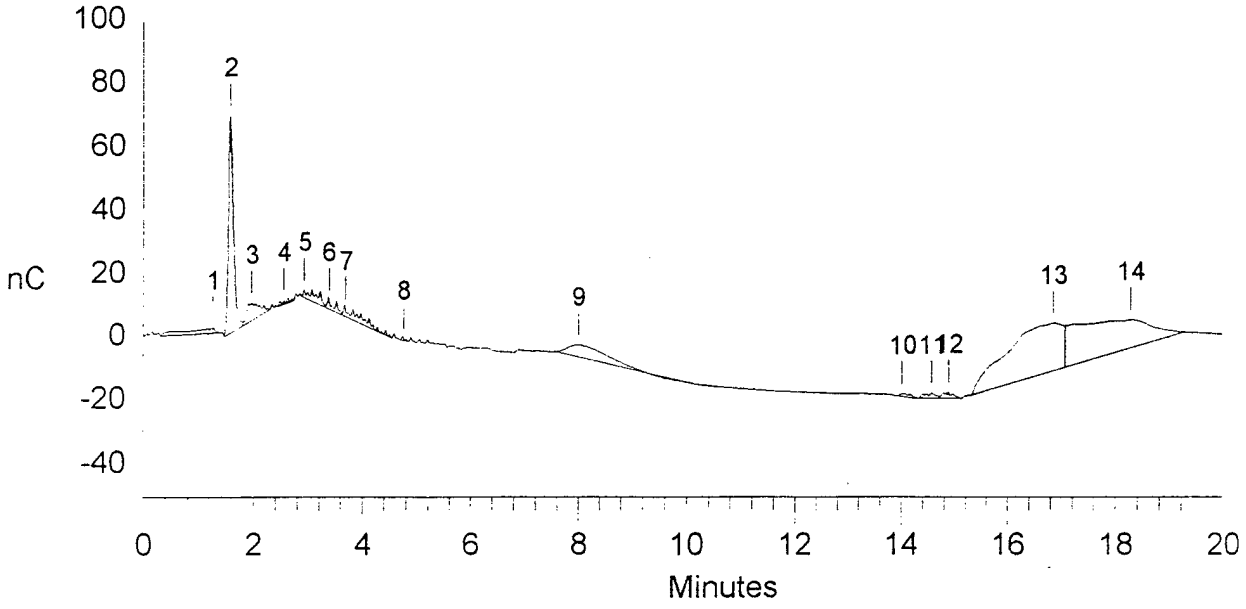
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
8	4.75	butylcarb	0.254	5765	40702	1	4.78
		Totals	0.254	5765	40702		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.27		0.000	14662	681472	1	
2	1.58		0.000	680245	4335773	2	
3	1.97		0.000	54000	868450	2	
4	2.55		0.000	12032	109646	1	
5	2.93		0.000	22046	491915	2	
6	3.38		0.000	25104	268361	2	
7	3.68		0.000	22462	704569	2	
9	8.00		0.000	37231	1925693	1	
10	14.02		0.000	9589	142353	1	
11	14.57		0.000	16345	226292	2	
12	14.88		0.000	20145	242418	2	
13	16.85		0.000	149913	11721359	2	
14	18.27		0.000	89369	10323213	2	
		Totals	0.000	1153146	32041513		

File: afff0017.DXD Sample B2 end of feed--60ppm



Data File	: c:\peaknet\data\afff0018.DXD	Report Date	: 11/3/97 1:51:41 AM
Sample Name	: B3 end of feed--60ppm	Collected	: 11/3/97 1:23:21 AM
Inject #	: 18	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

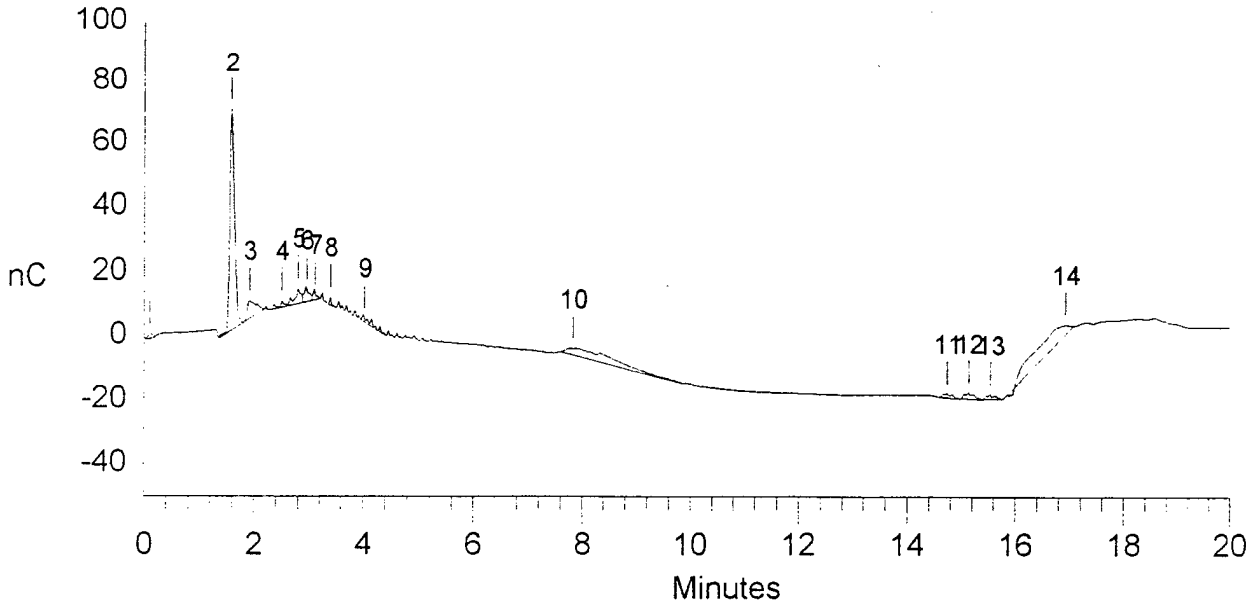
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	0.10		0.000	15252	85527	1	
2	1.58		0.000	688472	4204967	1	
3	1.92		0.000	55558	593758	1	
4	2.50		0.000	20793	124110	2	
5	2.80		0.000	46017	372540	2	
6	2.97		0.000	33714	272112	2	
7	3.12		0.000	15128	117603	2	
8	3.40		0.000	24785	73735	1	
9	4.02		0.000	10703	213414	1	
10	7.83		0.000	20808	1779034	1	
11	14.73		0.000	13638	180974	1	
12	15.13		0.000	18990	227420	1	
13	15.53		0.000	14156	159182	1	
14	16.92		0.000	30482	2522942	1	
		Totals	0.000	1008497	10927318		

File: afff0018.DXD Sample B3 end of feed--60ppm



Data File	: c:\peaknet\data\afff0020.DXD	Report Date	: 11/3/97 2:48:39 AM
Sample Name	: A1 end of anaerobic--control	Collected	: 11/3/97 2:20:19 AM
Inject #	: 20	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

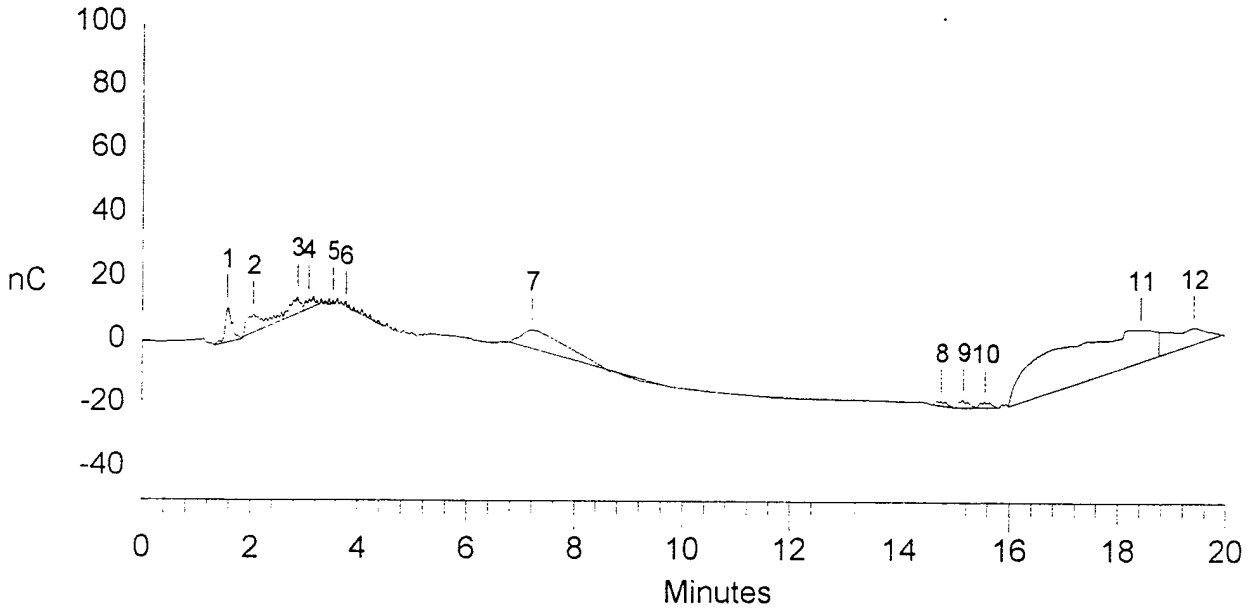
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.57		0.000	107804	1018325	1	
2	2.05		0.000	56142	1379145	2	
3	2.87		0.000	53976	658026	2	
4	3.08		0.000	31952	362311	2	
5	3.53		0.000	14130	67279	1	
6	3.78		0.000	9442	244421	1	
7	7.20		0.000	58407	3385224	1	
8	14.75		0.000	15246	211561	1	
9	15.15		0.000	23603	301924	2	
10	15.55		0.000	19094	262880	2	
11	18.42		0.000	102176	18070125	2	
12	19.40		0.000	50038	1473832	2	
		Totals	0.000	542011	27435053		

File: afff0020.DXD Sample A1 end of anaerobic--control



Data File	: c:\peaknet\data\afff0021.DXD	Report Date	: 11/3/97 3:17:07 AM
Sample Name	: A2 end of anaerobic--control	Collected	: 11/3/97 2:48:48 AM
Inject #	: 21	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

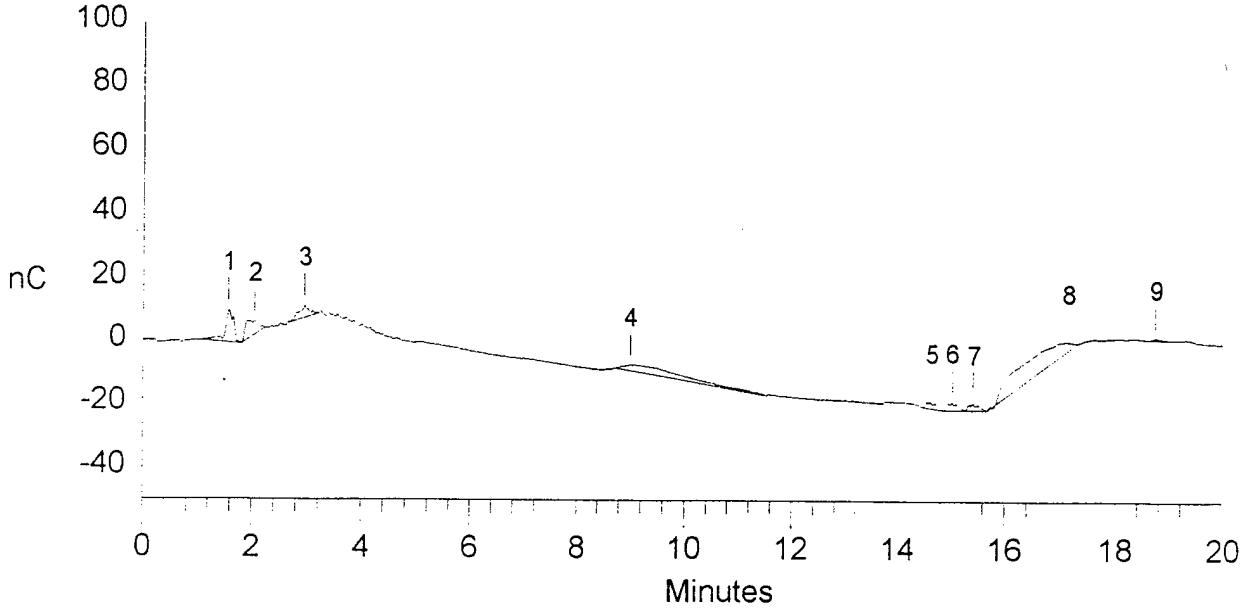
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.57		0.000	100286	1099125	1	
2	2.05		0.000	42130	803456	1	
3	2.95		0.000	36483	477402	1	
4	9.00		0.000	18486	1913500	1	
5	14.62		0.000	19697	262051	1	
6	15.02		0.000	26173	329269	2	
7	15.42		0.000	21360	273389	2	
8	17.13		0.000	27415	4289561	1	
9	18.72		0.000	5853	70265	1	
		Totals	0.000	297884	9518017		

File: afff0021.DXD Sample A2 end of anaerobic--control



Data File	: c:\peaknet\data\afff0022.DXD	Report Date	: 11/3/97 3:45:37 AM
Sample Name	: A3 end of anaerobic--control	Collected	: 11/3/97 3:17:15 AM
Inject #	: 22	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

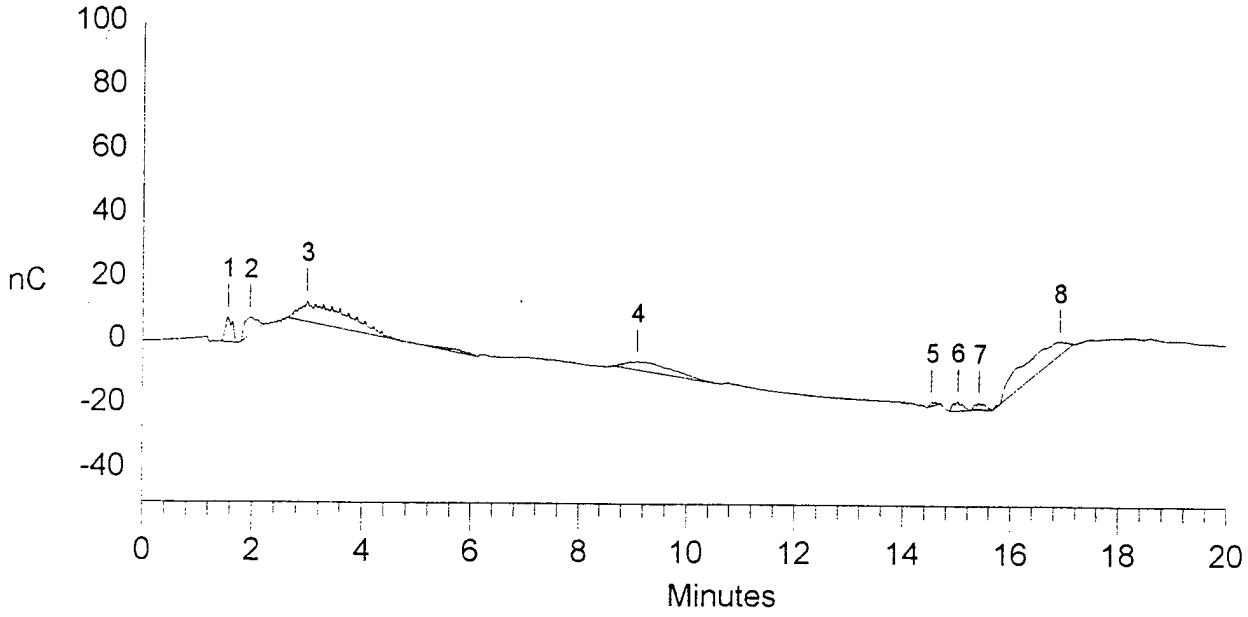
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.55		0.000	78653	724030	1	
2	1.95		0.000	54075	847460	1	
3	2.98		0.000	64556	4327621	1	
4	9.08		0.000	25865	1740498	1	
5	14.53		0.000	12794	77652	1	
6	15.02		0.000	27662	347964	1	
7	15.42		0.000	20097	259181	1	
8	16.90		0.000	40144	3951285	1	
		Totals	0.000	323848	12275691		

File: afff0022.DXD Sample A3 end of anaerobic--control



Data File	: c:\peaknet\data\afff0023.DXD	Report Date	: 11/3/97 4:14:07 AM
Sample Name	: B1 end of anaerobic--60ppm	Collected	: 11/3/97 3:45:45 AM
Inject #	: 23	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

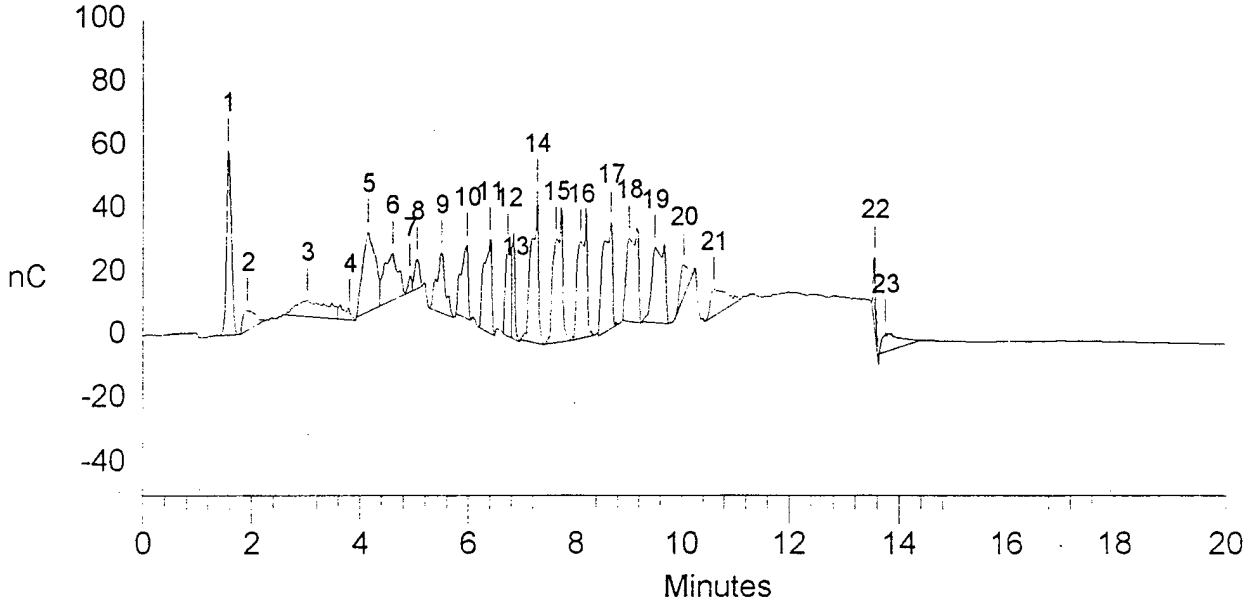
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
6	4.60	butylcarb	16.877	148491	2703590	2	1.47
		Totals	16.877	148491	2703590		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.57		0.000	581871	3677722	1	
2	1.92		0.000	63479	967984	1	
3	3.02		0.000	52869	2184917	2	
4	3.80		0.000	28595	232682	2	
5	4.15		0.000	253137	4146095	2	
7	4.92		0.000	52122	243409	2	
8	5.05		0.000	93788	574691	2	
9	5.50		0.000	189897	2199456	1	
10	5.97		0.000	231093	2152332	1	
11	6.40		0.000	297997	2892131	1	
12	6.73		0.000	287624	2022509	2	
13	6.87		0.000	143608	1183580	2	
14	7.28		0.000	480202	4308352	1	
15	7.63		0.000	329003	4413465	1	
16	8.10		0.000	306287	4268348	1	
17	8.67		0.000	336787	4146135	1	
18	9.02		0.000	265706	4013997	1	
19	9.50		0.000	237106	3936456	1	
20	10.03		0.000	102103	1050331	1	
21	10.60		0.000	86651	1726012	1	
22	13.55		0.000	225350	644911	1	
23	13.75		0.000	62931	1222559	1	
		Totals	0.000	4708205	52208071		

File: afff0023.DXD Sample B1 end of anaerobic--60ppm



Data File	: c:\peaknet\data\afff0024.DXD	Report Date	: 11/3/97 4:42:37 AM
Sample Name	: B2 end of anaerobic--60ppm	Collected	: 11/3/97 4:14:15 AM
Inject #	: 24	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

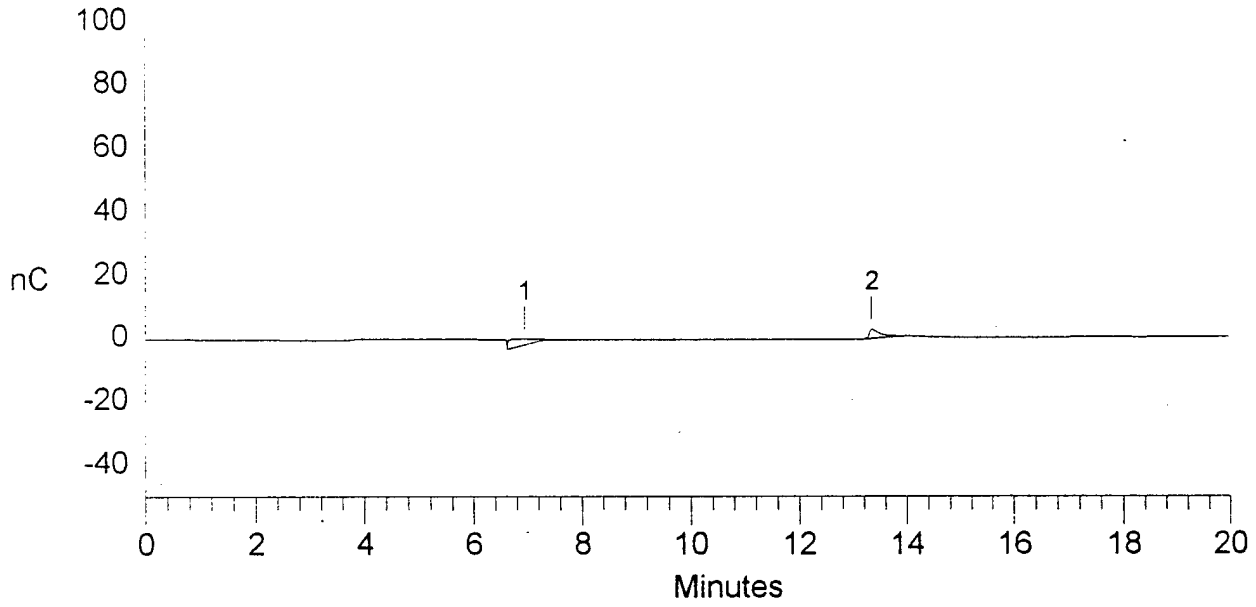
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

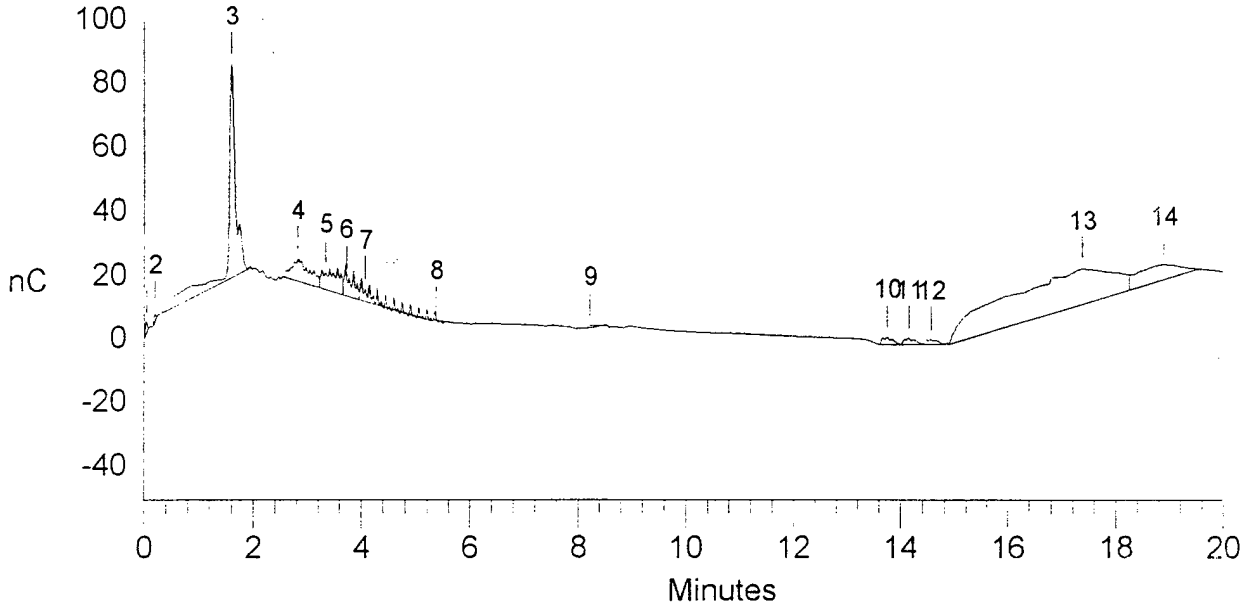
********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	6.93		0.000	18791	664023	1	
2	13.33		0.000	30180	416574	1	
		Totals	0.000	48971	1080597		

File: afff0024.DXD Sample B2 end of anaerobic--60ppm



File: afff0030.DXD Sample B1 end of aerobic--60pm



Data File	: c:\peaknet\data\afff0031.DXD	Report Date	: 11/3/97 11:27:16 AM
Sample Name	: B2 end of aerobic--60ppm	Collected	: 11/3/97 10:58:58 AM
Inject #	: 31	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

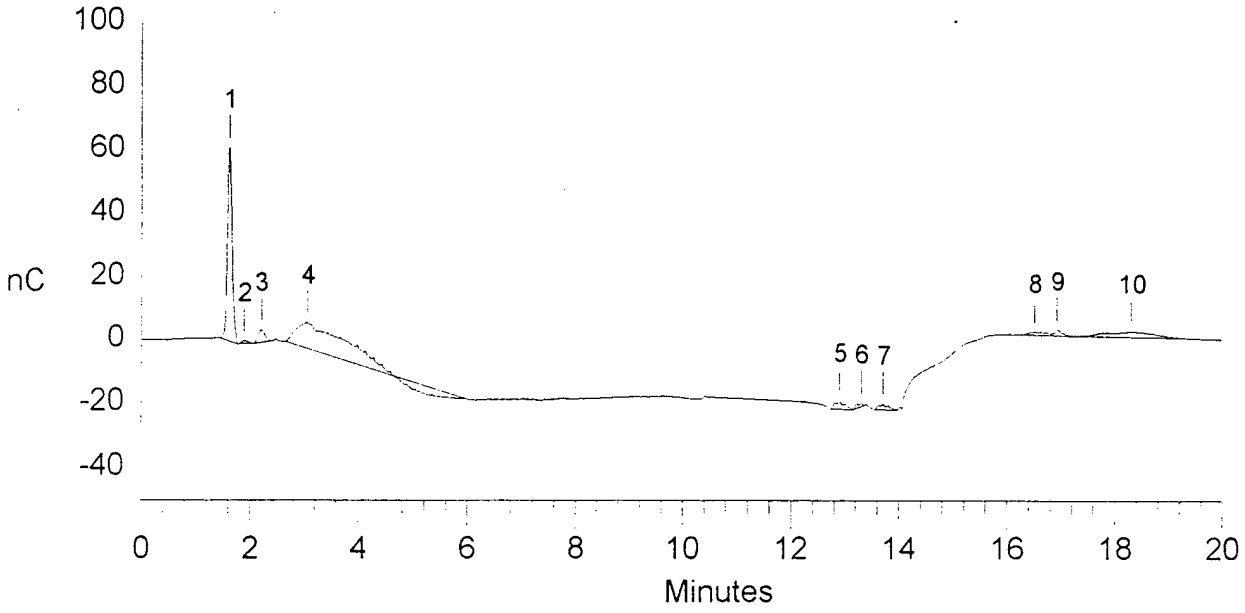
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.62		0.000	608805	3635766	1	
2	1.88		0.000	9111	69686	1	
3	2.20		0.000	38757	352877	1	
4	3.07		0.000	82525	4680119	1	
5	12.90		0.000	22774	301826	1	
6	13.30		0.000	11214	87067	1	
7	13.70		0.000	17321	209009	1	
8	16.50		0.000	9773	230808	2	
9	16.92		0.000	19228	196443	2	
10	18.30		0.000	17322	1125172	1	
		Totals	0.000	836829	10888773		

File: afff0031.DXD Sample B2 end of aerobic--60ppm



Data File	: c:\peaknet\data\afff0032.DXD	Report Date:	11/3/97 11:55:45 AM
Sample Name:	B3 end of aerobic--60ppm	Collected	: 11/3/97 11:27:26 AM
Inject #	: 32	Vial #	:
Method File:	c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name:	DX-500	Detector	: ED40
Column Type:		Operator	:
Data Points:	1200	Rate	: 1.00 Hz
Module Name:	ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

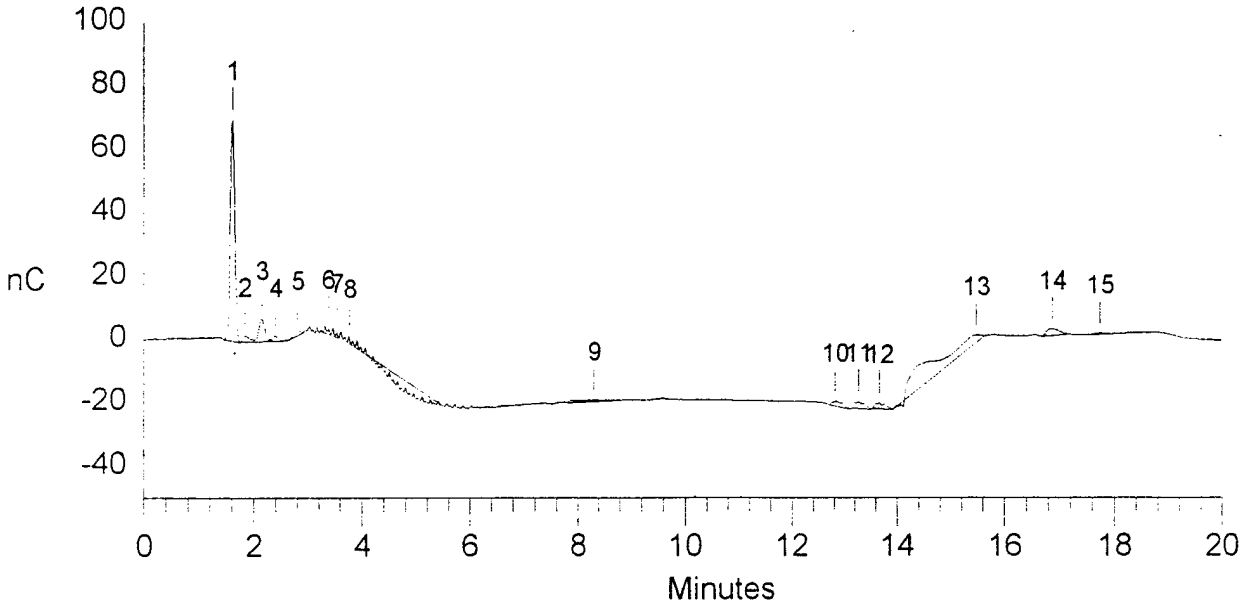
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.62		0.000	696627	4009245	1	
2	1.83		0.000	18940	171438	2	
3	2.15		0.000	71116	552582	2	
4	2.40		0.000	16053	112345	2	
5	2.80		0.000	19373	159557	1	
6	3.38		0.000	18555	103199	2	
7	3.53		0.000	15620	93018	2	
8	3.77		0.000	20749	1301455	1	
9	8.30		0.000	4765	231369	1	
10	12.82		0.000	15549	228173	1	
11	13.27		0.000	22219	287466	1	
12	13.67		0.000	19694	248433	1	
13	15.47		0.000	25359	3572524	1	
14	16.87		0.000	22190	351848	1	
15	17.73		0.000	4021	48742	1	
		Totals	0.000	990830	11471394		

File: afff0032.DXD Sample B3 end of aerobic--60ppm



Schedule: \peaknet\schedule\afff11_2.sch
Release 4.30 Page 2 of 2 11/3/97 11:55:46 AM

Data File	: c:\peaknet\data\afff0033.DXD	Report Date	: 11/3/97 12:24:12 PM
Sample Name	: STANDARD 3-10ppm	Collected	: 11/3/97 11:55:53 AM
Inject #	: 33	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

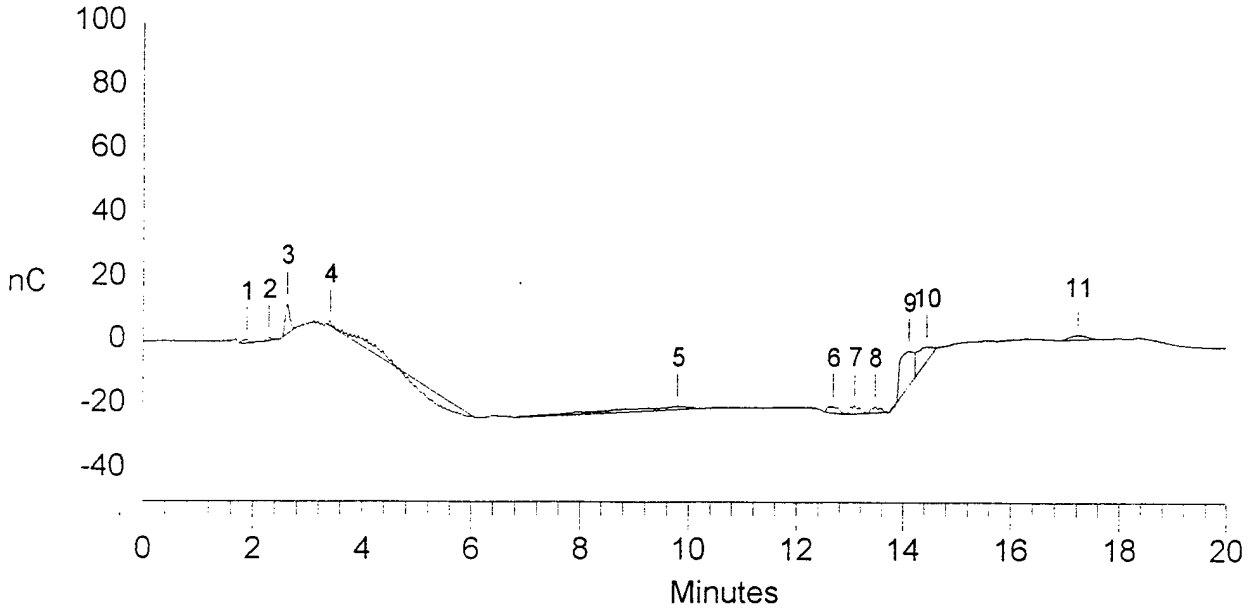
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.88		0.000	10969	85747	1	
2	2.28		0.000	11441	74416	1	
3	2.62		0.000	95822	538273	1	
4	3.42		0.000	15775	657240	1	
5	9.80		0.000	9689	1170617	1	
6	12.68		0.000	19614	289698	1	
7	13.08		0.000	24681	331846	1	
8	13.47		0.000	18537	222960	1	
9	14.10		0.000	107278	1969890	2	
10	14.43		0.000	44220	983595	2	
11	17.22		0.000	13815	307906	1	
		Totals	0.000	371840	6632187		

File: afff0033.DXD Sample STANDARD 3-10ppm



Data File	: c:\peaknet\data\afff0034.DXD	Report Date	: 11/3/97 12:52:40 PM
Sample Name	: A1 end of settle--control	Collected	: 11/3/97 12:24:20 PM
Inject #	: 34	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

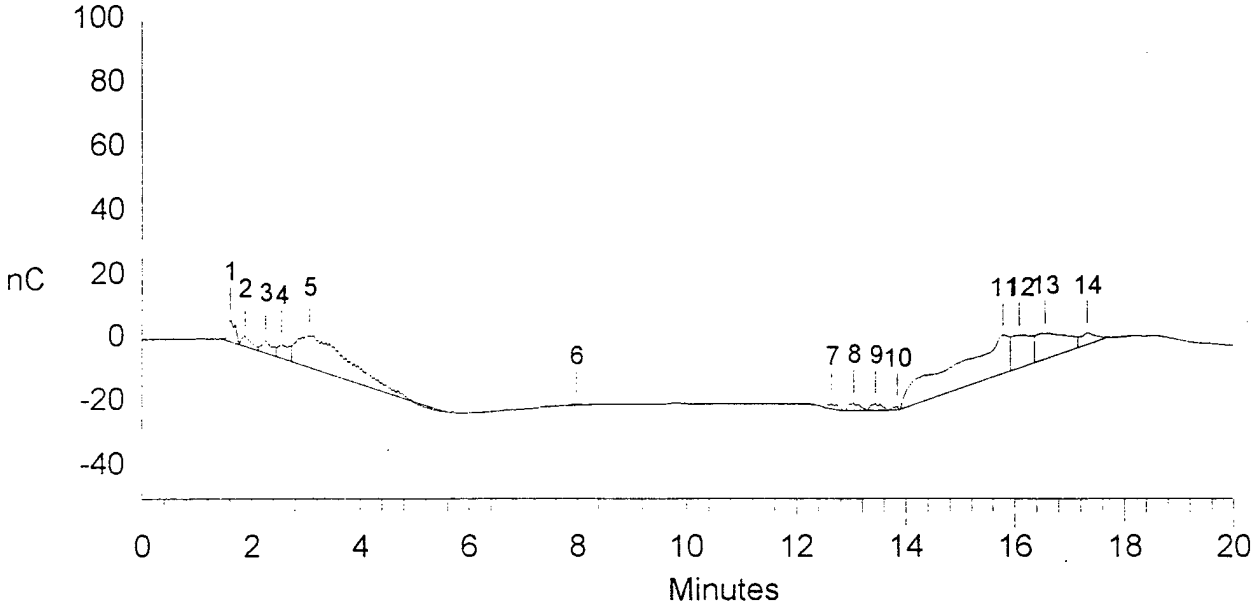
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.60		0.000	70406	669638	2	
2	1.87		0.000	33000	434800	2	
3	2.25		0.000	39588	574462	2	
4	2.55		0.000	47346	677110	2	
5	3.07		0.000	102020	7075674	2	
6	7.98		0.000	3715	37783	1	
7	12.63		0.000	13830	200863	1	
8	13.03		0.000	25097	339764	2	
9	13.43		0.000	23100	311820	2	
10	13.83		0.000	11414	84491	1	
11	15.78		0.000	120144	9602106	2	
12	16.08		0.000	102650	2542203	2	
13	16.55		0.000	81308	3056759	2	
14	17.32		0.000	36177	651916	2	
		Totals	0.000	709796	26259389		

File: afff0034.DXD Sample A1 end of settle--control



Data File	: c:\peaknet\data\afff0035.DXD	Report Date	: 11/3/97 1:21:11 PM
Sample Name	: A2 end of settle--control	Collected	: 11/3/97 12:52:48 PM
Inject #	: 35	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

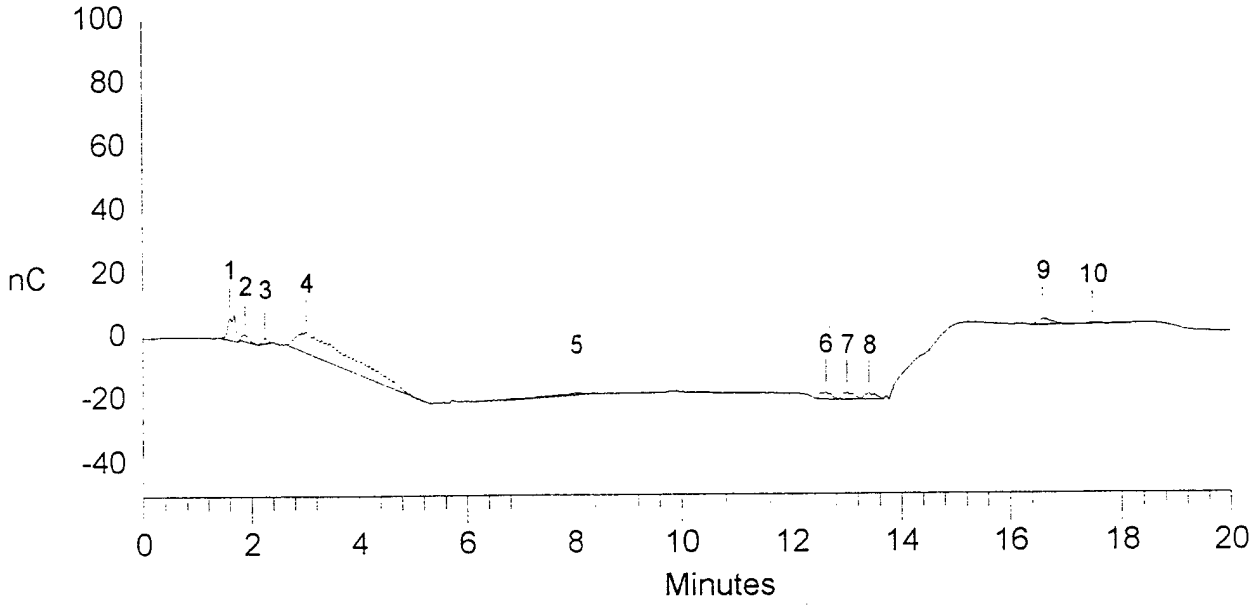
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.60		0.000	69488	750126	1	
2	1.88		0.000	21340	203220	1	
3	2.25		0.000	16588	109247	1	
4	3.02		0.000	67032	5254413	1	
5	8.03		0.000	5580	252489	1	
6	12.62		0.000	21924	309643	1	
7	13.00		0.000	20808	281658	2	
8	13.40		0.000	19219	252303	2	
9	16.60		0.000	18582	320398	1	
10	17.48		0.000	4081	48810	1	
		Totals	0.000	264643	7782307		

File: afff0035.DXD Sample A2 end of settle--control



Data File	: c:\peaknet\data\afff0036.DXD	Report Date	: 11/3/97 1:49:41 PM
Sample Name	: A3 end of settle--control	Collected	: 11/3/97 1:21:19 PM
Inject #	: 36	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

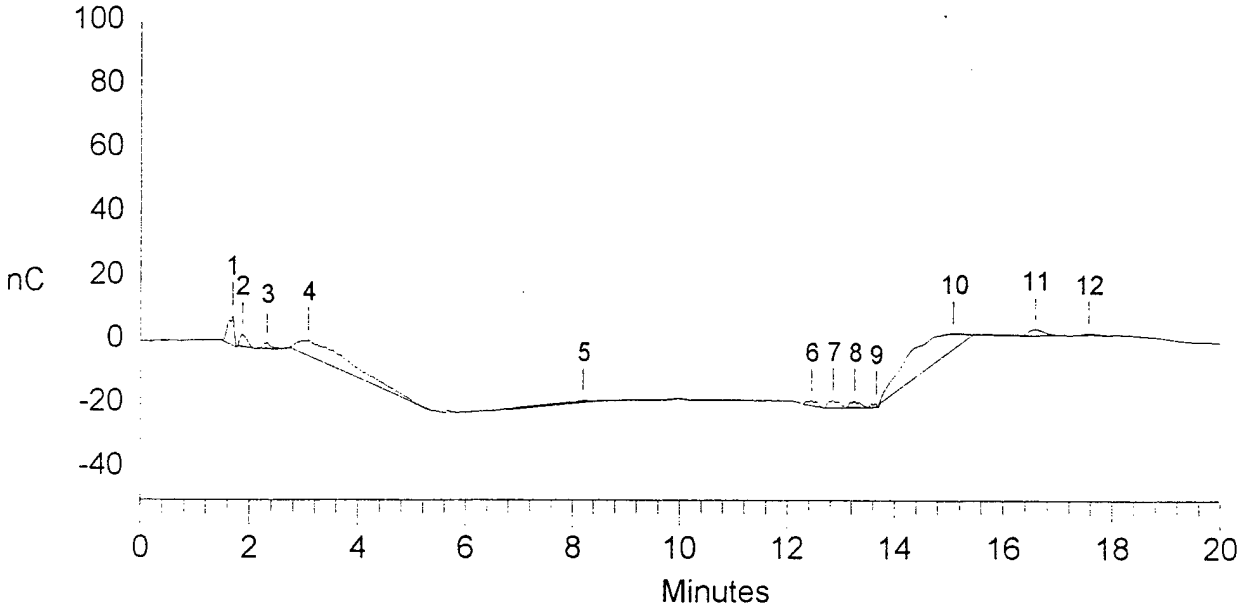
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.68		0.000	96669	762671	1	
2	1.87		0.000	37743	347577	1	
3	2.32		0.000	18237	164863	1	
4	3.08		0.000	48865	3864357	1	
5	8.20		0.000	5214	306663	1	
6	12.45		0.000	15489	215466	1	
7	12.85		0.000	24772	331377	2	
8	13.25		0.000	20861	273990	2	
9	13.65		0.000	11321	78122	1	
10	15.08		0.000	49341	6169717	1	
11	16.57		0.000	19091	367986	1	
12	17.55		0.000	4535	61938	1	
		Totals	0.000	352139	12944726		

File: afff0036.DXD Sample A3 end of settle--control



Schedule: \peaknet\schedule\afff11_2.sch

Data File	: c:\peaknet\data\afff0037.DXD	Report Date	: 11/3/97 2:18:09 PM
Sample Name	: B1 end of settle--60ppm	Collected	: 11/3/97 1:49:48 PM
Inject #	: 37	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

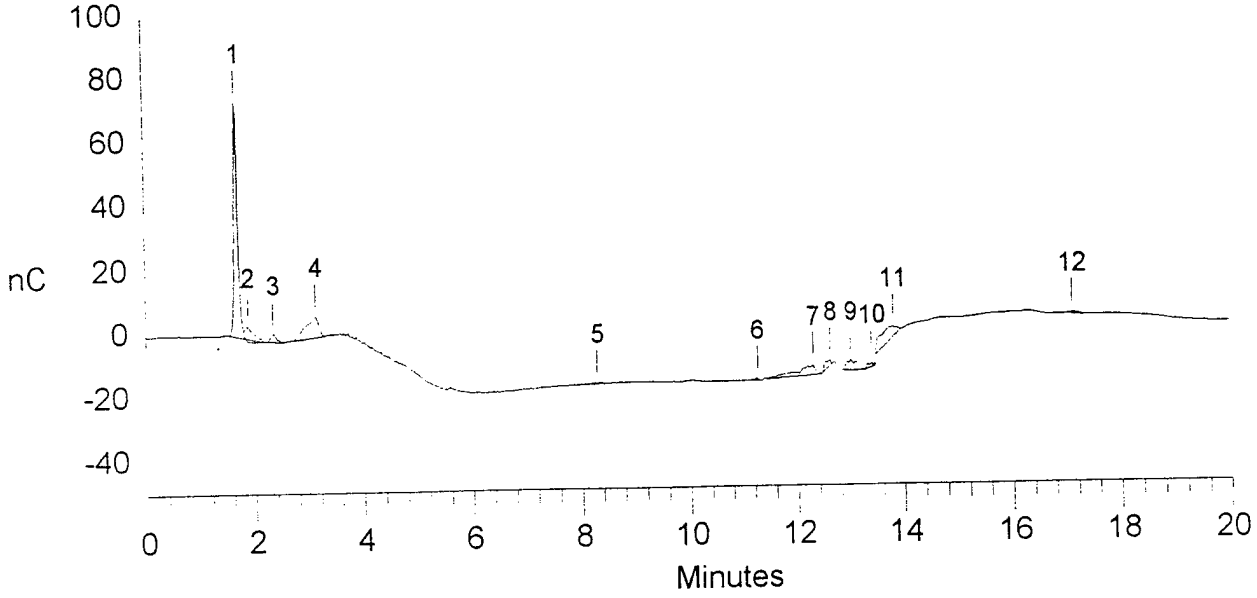
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.67		0.000	731756	3594938	3	
2	1.87		0.000	45162	549883	4	
3	2.33		0.000	24952	190974	1	
4	3.12		0.000	64692	1132008	1	
5	8.28		0.000	4061	43338	1	
6	11.25		0.000	5036	30743	1	
7	12.28		0.000	29980	742390	1	
8	12.60		0.000	16870	169948	1	
9	12.98		0.000	31510	439257	1	
10	13.38		0.000	11383	86009	1	
11	13.80		0.000	30956	910981	1	
12	17.10		0.000	6116	91389	1	
		Totals	0.000	1002473	7981857		

File: afff0037.DXD Sample B1 end of settle--60ppm



Data File	: c:\peaknet\data\afff0038.DXD	Report Date	: 11/3/97 2:46:37 PM
Sample Name	: B2 end of settle--60ppm	Collected	: 11/3/97 2:18:17 PM
Inject #	: 38	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

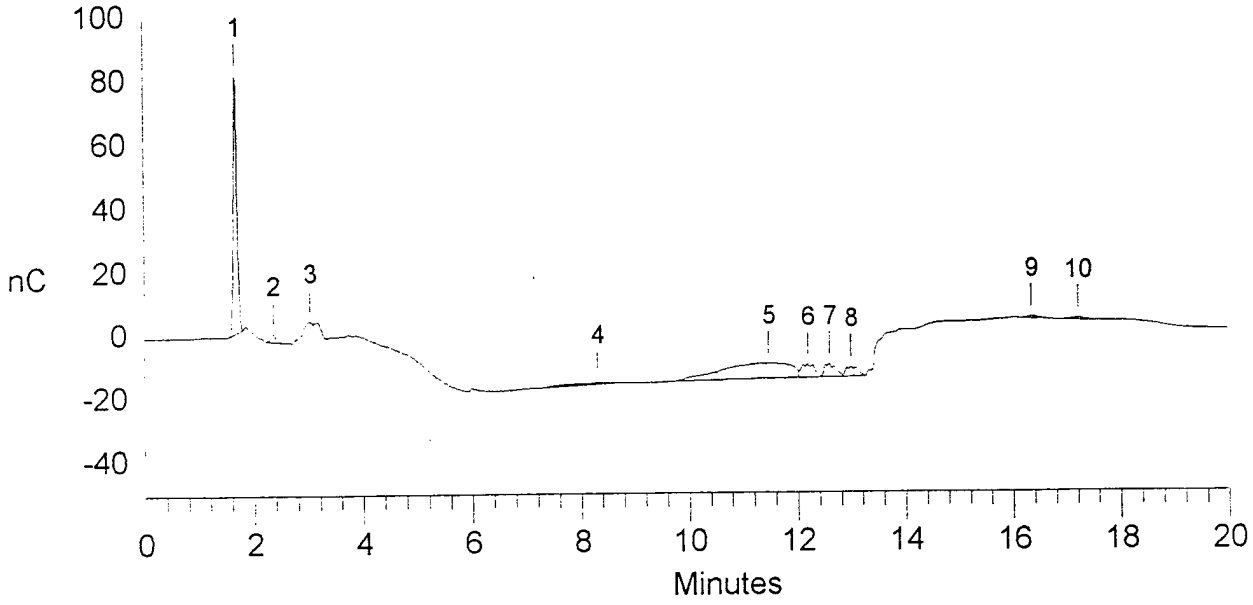
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.67		0.000	807134	3788001	1	
2	2.35		0.000	25120	170123	1	
3	3.02		0.000	18797	279215	1	
4	8.30		0.000	5800	306504	1	
5	11.47		0.000	46886	4236383	2	
6	12.18		0.000	42077	695237	2	
7	12.58		0.000	42530	597959	2	
8	12.98		0.000	32363	472836	2	
9	16.33		0.000	6258	98575	1	
10	17.20		0.000	5398	81695	1	
		Totals	0.000	1032364	10726528		

File: afff0038.DXD Sample B2 end of settle--60ppm



Data File	: c:\peaknet\data\afff0039.DXD	Report Date	: 11/3/97 3:15:06 PM
Sample Name	: B3 end of settle--60ppm	Collected	: 11/3/97 2:46:45 PM
Inject #	: 39	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

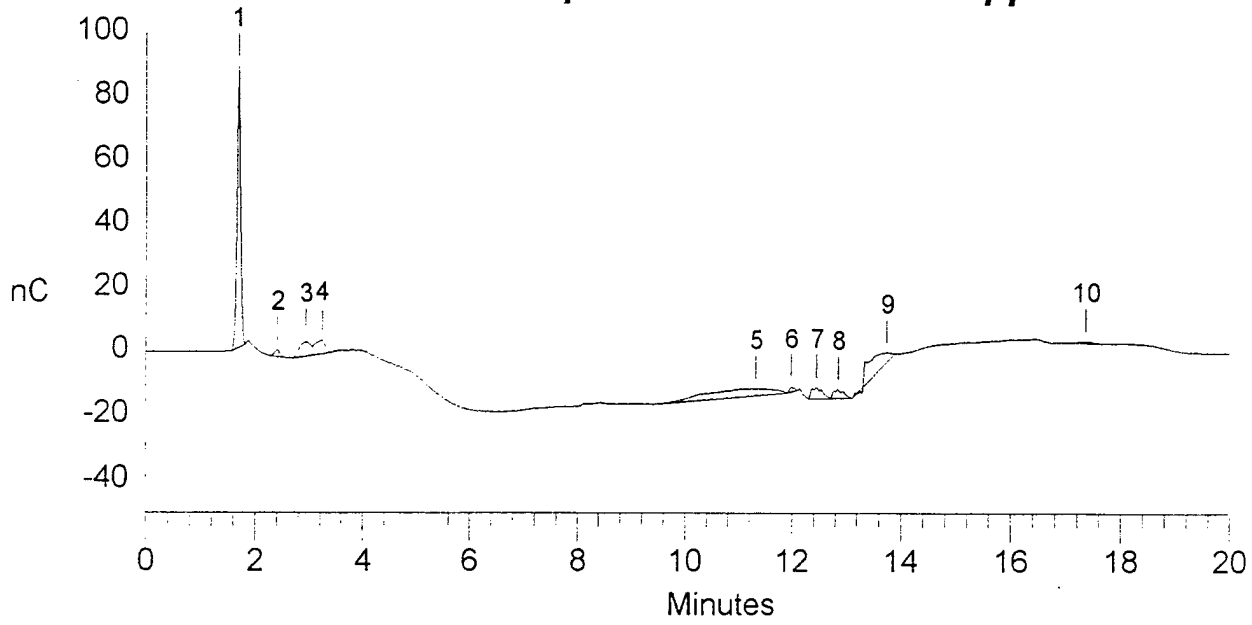
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.68		0.000	878640	4085513	1	
2	2.40		0.000	22488	144821	1	
3	2.93		0.000	44389	642685	2	
4	3.23		0.000	44063	579254	2	
5	11.32		0.000	21378	2181840	1	
6	11.98		0.000	14029	95452	1	
7	12.45		0.000	34516	473184	2	
8	12.85		0.000	27980	369718	2	
9	13.73		0.000	30548	1457236	1	
10	17.35		0.000	4947	80618	1	
		Totals	0.000	1122978	10110321		

File: afff0039.DXD Sample B3 end of settle--60ppm



Data File	: c:\peaknet\data\afff0040.DXD	Report Date	: 11/3/97 3:43:34 PM
Sample Name	: STANDARD 4-50ppm	Collected	: 11/3/97 3:15:14 PM
Inject #	: 40	Vial #	:
Method File	: c:\peaknet\method\afff.met	Calibrated	: 11/2/97 10:04:00 PM
System Name	: DX-500	Detector	: ED40
Column Type	:	Operator	:
Data Points	: 1200	Rate	: 1.00 Hz
Module Name	: ID:24 0a 85	Moduleware	: 1.17

Calibration	Volume	Dilution	Start	Stop	Area Reject	Pk. Width	Threshold
External	1	1	0.00	19.98	1000	10.00	19.21

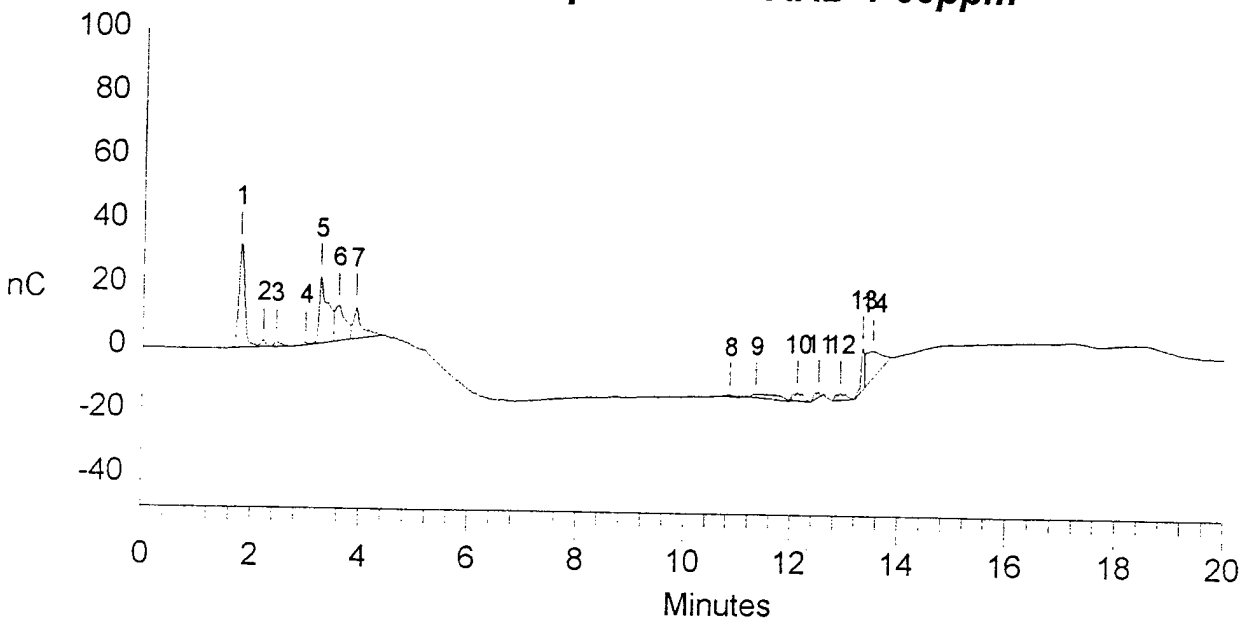
********** Component Report: All Components **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
0	0.00	butylcarb	0.000	0	0	0	0.00
		Totals	0.000	0	0		

********** Peak Report: Unknown Peaks **********

Pk. Num	Ret Time	Component Name	Concentration	Height	Area	Bl. Code	%Delta
1	1.78		0.000	325296	2429357	2	
2	2.20		0.000	24002	170707	2	
3	2.45		0.000	18971	148875	2	
4	2.98		0.000	7210	50711	2	
5	3.27		0.000	209860	2375017	2	
6	3.60		0.000	111458	1482906	2	
7	3.92		0.000	101553	1071935	2	
8	10.85		0.000	5067	65565	1	
9	11.33		0.000	10457	466714	1	
10	12.12		0.000	24539	337970	1	
11	12.52		0.000	14869	125229	1	
12	12.92		0.000	22302	278019	1	
13	13.32		0.000	133338	609577	2	
14	13.52		0.000	84206	1622195	2	
		Totals	0.000	1093126	11234776		

File: afff0040.DXD Sample STANDARD 4-50ppm



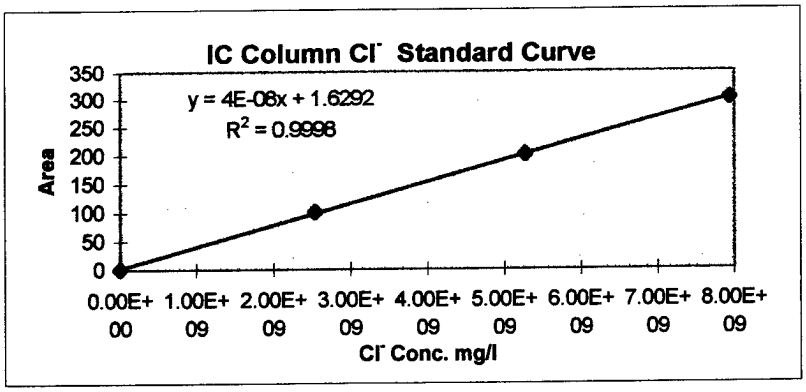
APPENDIX B

BNR Inhibition Batch Assays Pretreated with Defoamers

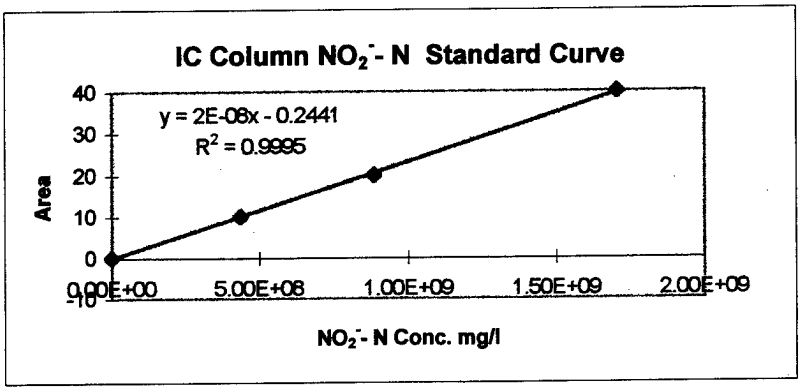
BNR Inhibition Batch Assay Pretreated with Defoamer 8710

(AFFF 60 ppm)

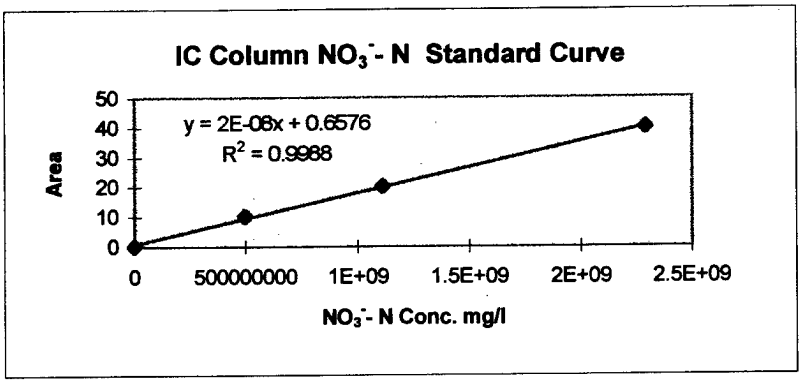
Reactor	AFFF (ppm)	Defoamer 8710 ml/liter	Stage	Time	NH3-N (mg/L)	TKN (mg/L)
			Feedstock		30.50	149.29
			RR Decant		1.58	1.56
A1	0	0	End of Feeding	2 hr	21.25	26.55
			End of Anaerobic	4 hr	23.46	31.09
			End of Aerobic	6 hr	6.59	15.24
			End of Settling	8 hr	5.85	6.34
A2	0	0	End of Feeding	2 hr	21.25	24.28
			End of Anaerobic	4 hr	22.56	29.65
			End of Aerobic	6 hr	6.34	13.90
			End of Settling	8 hr	6.32	6.34
A3	0	0	End of Feeding	2 hr	19.62	33.22
			End of Anaerobic	4 hr	21.68	26.96
			End of Aerobic	6 hr	6.10	11.45
			End of Settling	8 hr	5.20	7.31
B1	60	75	End of Feeding	2 hr	17.41	47.54
			End of Anaerobic	4 hr	20.03	32.60
			End of Aerobic	6 hr	21.40	26.96
			End of Settling	8 hr	22.99	29.10
B2	60	75	End of Feeding	2 hr	16.73	39.74
			End of Anaerobic	4 hr	20.03	35.86
			End of Aerobic	6 hr	20.58	26.96
			End of Settling	8 hr	22.11	26.45
B3	60	75	End of Feeding	2 hr	16.73	43.46
			End of Anaerobic	4 hr	19.26	37.60
			End of Aerobic	6 hr	20.58	22.29
			End of Settling	8 hr	22.11	30.51



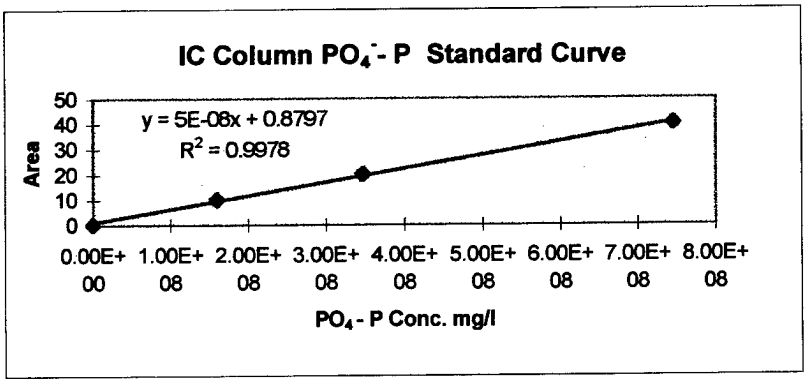
m = 4.00E-08
i = 1.62920588



m = 2.00E-08
i = -2.44E-01



m = 2.00E-08
i = 6.58E-01



m = 5.00E-08
i = 8.80E-01

Reactor	AFFF (ppm)	Defoamer 8710 ml/liter	Stage	Time	Cl- Area	Cl- (mg/L)	NO_2^--N Area	NO_2^--N (mg/L)	NO_3^--N Area	NO_3^--N (mg/L)	PO_4^--P Area	PO_4^--P (mg/L)
			Feedstock		7457747666	282.4	0	0.0	3524379	0.7	507017629	27.8
			RR Decant		5623726490	213.4	0	0.0	1706044005	30.1	10153030	1.4
A1	0	0	End of Feeding	2 hr	5041945872	191.5	0	0.0	2758118	0.7	**	**
			End of Anaerobic	4 hr	5027455061	190.9	0	0.0	2964817	0.7	944779425	51.0
			End of Aerobic	6 hr	5053058153	191.9	85235354	1.8	1291777953	22.9	562010370	30.7
			End of Settling	8 hr	5088956393	193.2	78609565	1.6	1341478644	23.8	552997441	30.2
A2	0	0	End of Feeding	2 hr	5127400412	194.7	0	0.0	1329484	0.7	**	**
			End of Anaerobic	4 hr	4946719672	187.9	0	0.0	817360	0.7	958696272	51.8
			End of Aerobic	6 hr	5003826950	190.0	75976408	1.5	1278850617	22.7	493873713	27.1
			End of Settling	8 hr	5117089552	194.3	73973601	1.5	1315150459	23.3	495640650	27.2
A3	0	0	End of Feeding	2 hr	5091896779	193.3	0	0.0	226258	0.7	913093284	49.3
			End of Anaerobic	4 hr	4940329563	187.6	0	0.0	1800473	0.7	1002070135	54.1
			End of Aerobic	6 hr	4975297553	188.9	91086799	1.9	1255680352	22.3	545344963	29.8
			End of Settling	8 hr	5056091891	192.0	81130861	1.7	1416148773	25.1	547369867	29.9
B1	60	75	End of Feeding	2 hr	4977058840	189.0	0	0.0	111277732	2.6	907954312	49.1
			End of Anaerobic	4 hr	4737157675	180.0	0	0.0	4703645	0.7	1033593354	55.7
			End of Aerobic	6 hr	4857096710	184.5	72317154	1.4	102657989	2.4	760675975	41.3
			End of Settling	8 hr	5096308355	193.5	83028403	1.7	134183815	3.0	767856471	41.6
B2	60	75	End of Feeding	2 hr	4783930883	181.7	0	0.0	30003358	1.2	922896041	49.9
			End of Anaerobic	4 hr	4825396022	183.3	0	0.0	2363790	0.7	1051995712	56.7
			End of Aerobic	6 hr	4927322604	187.1	50259487	0.9	185767797	3.9	752829263	40.8
			End of Settling	8 hr	5028328616	190.9	52302672	1.0	202345313	4.1	754358389	40.9
B3	60	75	End of Feeding	2 hr	5079180104	192.9	0	0.0	870556	0.7	964491265	52.1
			End of Anaerobic	4 hr	4989264230	189.5	0	0.0	2805377	0.7	1119659940	60.3
			End of Aerobic	6 hr	5180772536	196.7	63924582	1.3	122078432	2.8	853373379	46.2
			End of Settling	8 hr	5414707806	205	58302078	1.12	147594599	3.2	832463719	45.1
			Stand 2		2537327961	97.2	436373497	10.0	498937800	9.3	157251445	9.2
			Stand 3		5201369190	197.5	877244997	20.3	1107112362	19.8	337460091	18.8
			Stand 4		8233404885	311.6	1.772E+09	41.2	2506862853	43.9	827751035	44.8
			Standards used									
			STD 1		112034	0	0	0	0	0	0	0
			STD 2		2546706893	100	437097596	10	499196654	10	159790402	10
			STD 3		5273486188	200	886725171	20	1111316466	20	346916597	20
			STD 4		7943185575	300	1.707E+09	40	2294176939	40	745786620	40

Phosphorus results derived from IC.

**Values not known

SUMMARY OUTPUT

CL

Regression Statistics	
R Square	0.999812763
Observations	4

	Coefficients	*Standard Error*
Intercept	1.629205877	1.797642711
X Variable 1	3.76492E-08	3.64315E-10

SUMMARY OUTPUT

NO2-N

Regression Statistics	
R Square	0.99953939
Observations	4

	Coefficients	*Standard Error*
Intercept	-0.244116398	0.35060654
X Variable 1	2.34176E-08	3.55463E-10

SUMMARY OUTPUT

NO3-N

Regression Statistics	
R Square	0.998799273
Observations	4

	Coefficients	*Standard Error*
Intercept	0.657555531	0.549397937
X Variable 1	1.72536E-08	4.23006E-10

SUMMARY OUTPUT

PO4-P

Regression Statistics	
R Square	0.997831646
Observations	4

	Coefficients	*Standard Error*
Intercept	0.879667485	0.733009284
X Variable 1	5.30792E-08	1.74963E-09

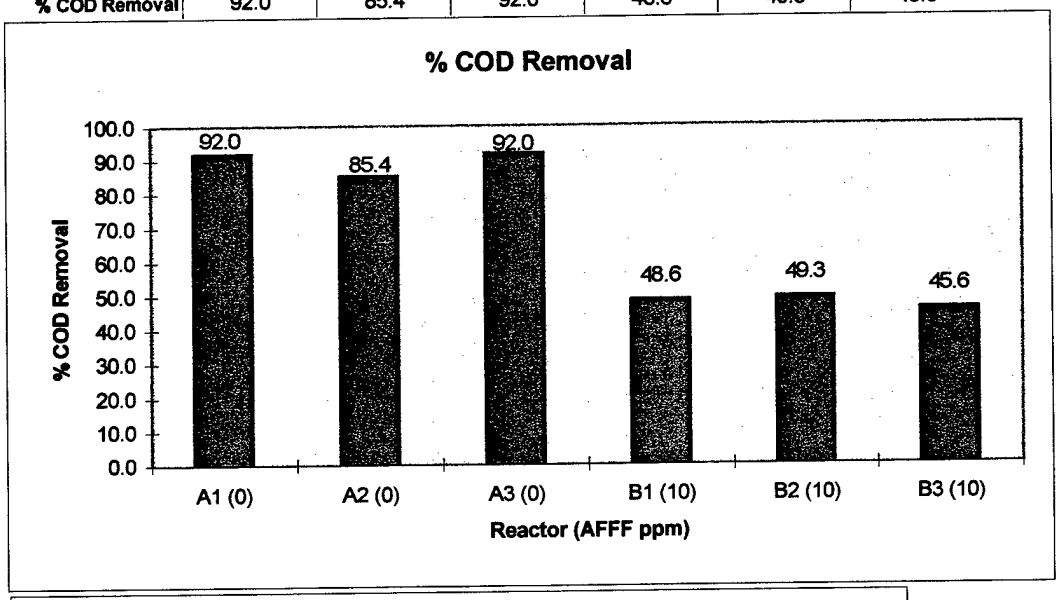
Reactor	AFFF (ppm)	Defoamer 8710 ml/liter	Stage	Time	COD		
					ABS	(mg/L)	% COD Removal *
			Feedstock		0.091	**1189.7**	
			RR Decant		0.001	**5.9**	
A1	0	0	End of Feeding	2 hr	0.012	**150.6**	62.4
			End of Anaerobic	4 hr	0.015	**190.0**	52.6
			End of Aerobic	6 hr	0.001	**5.9**	98.5
			End of Settling	8 hr	0.003	**32.2**	**92.0**
A2	0	0	End of Feeding	2 hr	0.012	**150.6**	62.4
			End of Anaerobic	4 hr	0.015	**190.0**	52.6
			End of Aerobic	6 hr	0.006	**71.6**	82.1
			End of Settling	8 hr	0.005	**58.5**	**85.4**
A3	0	0	End of Feeding	2 hr	0.010	**124.3**	69.0
			End of Anaerobic	4 hr	0.012	**150.6**	62.4
			End of Aerobic	6 hr	0.001	**5.9**	98.5
			End of Settling	8 hr	0.003	**32.2**	**92.0**
B1	60	75	End of Feeding	2 hr	0.053	**689.9**	61.7
			End of Anaerobic	4 hr	0.052	**676.7**	62.4
			End of Aerobic	6 hr	0.070	**913.5**	49.3
			End of Settling	8 hr	0.071	**926.7**	**48.6**
B2	60	75	End of Feeding	2 hr	0.058	**755.7**	58.0
			End of Anaerobic	4 hr	0.053	**689.9**	61.7
			End of Aerobic	6 hr	0.072	**939.8**	47.8
			End of Settling	8 hr	0.070	**913.5**	**49.3**
B3	60	75	End of Feeding	2 hr	0.055	**716.2**	60.2
			End of Anaerobic	4 hr	0.056	**729.3**	59.5
			End of Aerobic	6 hr	0.077	**1005.6**	44.2
			End of Settling	8 hr	0.075	**979.3**	**45.6**
			STD 1		0.000	0	
			STD 2		0.077	1000	
			STD 3		0.149	2000	
			STD 4		0.236	3000	
			STD 5		0.339	4500	
			FS (Filtered)		0.091	1189.7	
			FS Average		**0.091**	**1189.7**	
			RRSU(Filtered)		0.001	5.9	
			RRSU Average		**0.001**	**5.9**	

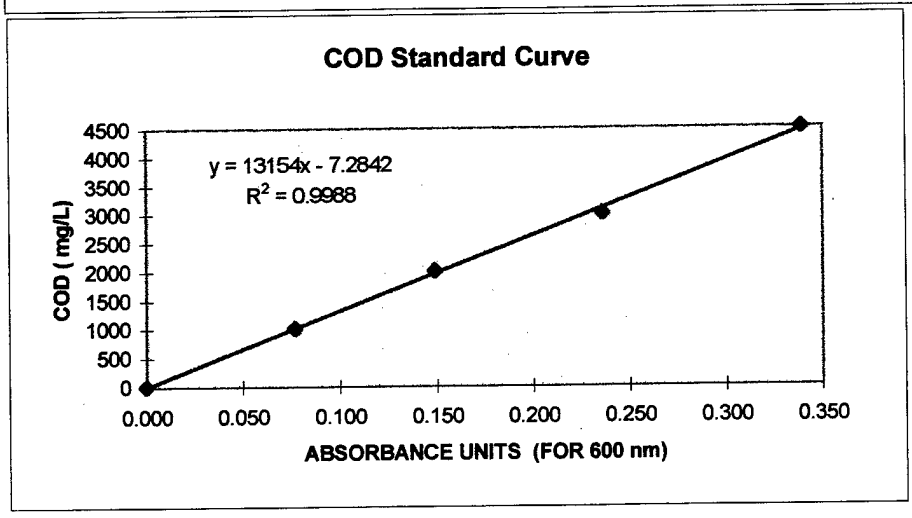
* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.

Initial COD at Time 0 hr.

Sample	Constituent	Vol (L)	COD mg/L	
Controls	RR Decant	4	5.9	23.4796981
(A1,A2&A3)	Feedstock	2	1189.7	2379.47486
	Defoamer	2	0	0
	AFFF	0	0	0
	Total	6		**400.5**
Inhibition	RR Decant	4	5.9	23.6
(B1,B2&B3)	Feedstock	2	1189.7	2379.4
	Defoamer	1	4930	4930
	AFFF	2	1737	3474
	Total	6		**1801.2**

Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (10)	B2 (10)	B3 (10)
% COD Removal	92.0	85.4	92.0	48.6	49.3	45.6





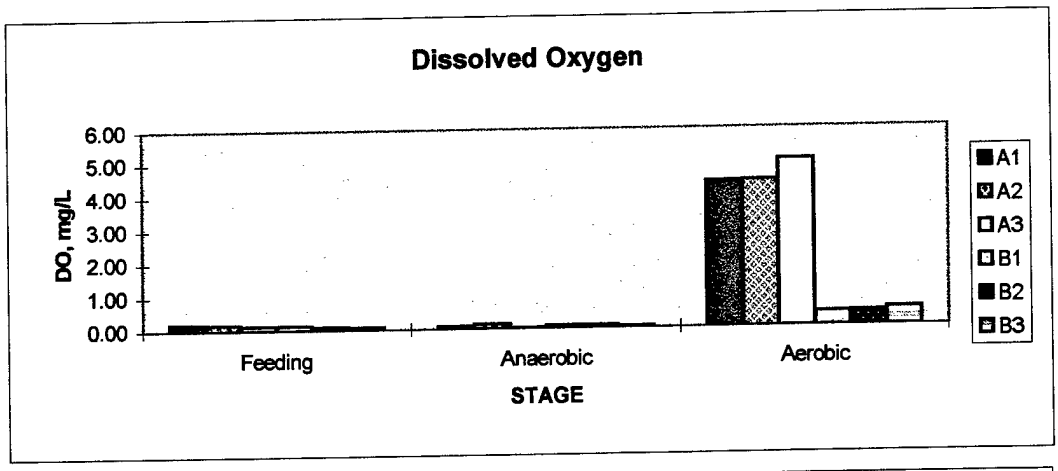
m = 13154
i = -7.2842

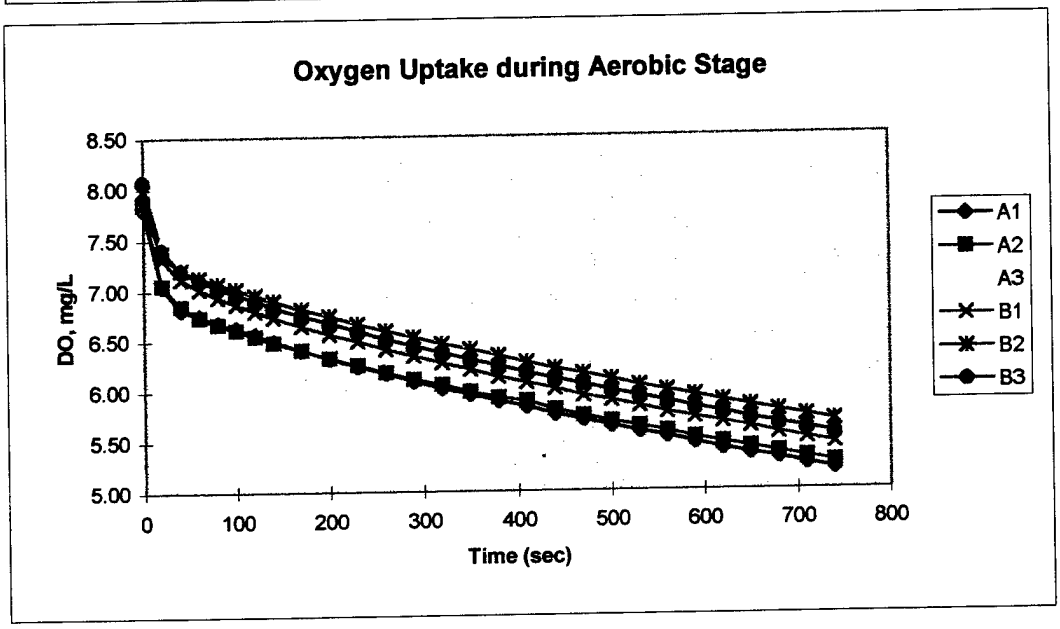
SUMMARY OUTPUT

COD

Regression Statistics	
R Square	0.998847775
Observations	5

	Coefficients	*Standard Error*
Intercept	-7.284158871	51.42618443
X Variable 1	13154.08339	257.9401893


Dissolved Oxygen
6.00
5.00
4.00
3.00
2.00
1.00
0.00
DO, mg/L
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3


Oxygen Uptake during Aerobic Stage
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
DO, mg/L
0
100
200
300
400
500
600
700
800
Time (sec)
A1
A2
A3
B1
B2
B3

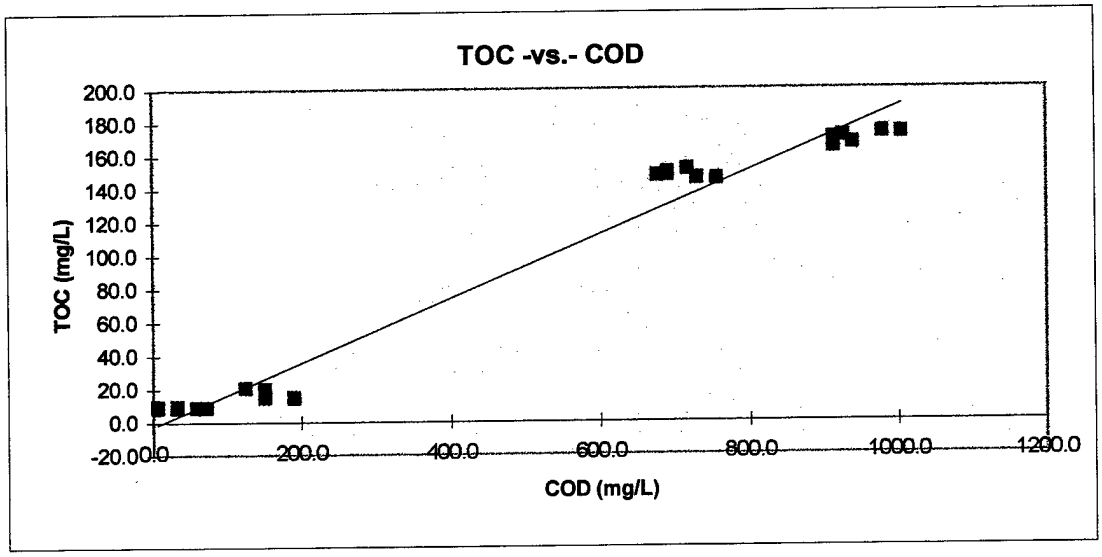
	Dissolved Oxygen (mg/L) at various stages					
Stage	A1	A2	A3	B1	B2	B3
Feeding	0.20	0.17	0.13	0.13	0.09	0.07
Anaerobic	0.07	0.13	0.02	0.07	0.08	0.03
Aerobic	4.38	4.40	5.02	0.41	0.43	0.53

		Dissolved Oxygen in mg/L					
Stage	Time (sec)	A1	A2	A3	B1	B2	B3
Aerobic	0	7.80	7.85	7.84	7.98	7.85	8.06
	20	7.04	7.05	7.46	7.31	7.37	7.40
	40	6.81	6.84	7.30	7.11	7.20	7.19
	60	6.74	6.73	7.23	7.01	7.12	7.10
	80	6.67	6.66	7.16	6.93	7.06	7.03
	100	6.62	6.60	7.11	6.86	7.01	6.96
	120	6.56	6.54	7.04	6.79	6.95	6.90
	140	6.49	6.48	6.98	6.73	6.89	6.83
	170	6.40	6.40	6.91	6.64	6.81	6.75
	200	6.32	6.32	6.83	6.56	6.74	6.67
	230	6.24	6.25	6.75	6.49	6.66	6.59
	260	6.17	6.18	6.69	6.41	6.59	6.51
	290	6.09	6.11	6.62	6.34	6.53	6.44
	320	6.02	6.05	6.56	6.27	6.46	6.37
	350	5.96	5.98	6.49	6.20	6.40	6.30
	380	5.89	5.92	6.43	6.13	6.34	6.24
	410	5.83	5.89	6.37	6.07	6.27	6.17
	440	5.76	5.80	6.32	6.01	6.21	6.11
	470	5.70	5.74	6.26	5.94	6.16	6.05
	500	5.64	5.68	6.20	5.89	6.10	5.99
	530	5.58	5.63	6.14	5.83	6.04	5.93
	560	5.53	5.58	6.09	5.77	5.99	5.88
	590	5.47	5.52	6.04	5.72	5.94	5.82
	620	5.41	5.47	5.99	5.67	5.88	5.77
	650	5.36	5.42	5.93	5.62	5.83	5.71
	680	5.31	5.37	5.88	5.56	5.78	5.66
	710	5.25	5.32	5.83	5.51	5.73	5.61
	740	5.20	5.27	5.78	5.46	5.68	5.56

Reactor	AFFF (ppm)	Defoamer 8710 ml/l	Stage	Time	Concentration, mg/L TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
			Feedstock		149.3	30.5	118.8	0.0	0.7	150.0	282.4	27.8
			RR Decant		1.6	1.6	0.0	0.0	30.1	31.7	213.4	1.4
A1	0	0	End of Feeding	2 hr	26.6	21.3	5.3	0.0	0.7	27.3	191.5	**
			End of Anaerobic	4 hr	31.1	23.5	7.6	0.0	0.7	31.8	190.9	51.0
			End of Aerobic	6 hr	15.2	6.6	8.7	1.8	22.9	39.9	191.9	30.7
			End of Settling	8 hr	6.3	5.9	0.5	1.6	23.8	31.7	193.2	30.2
A2	0	0	End of Feeding	2 hr	24.3	21.3	3.0	0.0	0.7	25.0	194.7	**
			End of Anaerobic	4 hr	29.7	22.6	7.1	0.0	0.7	30.3	187.9	51.8
			End of Aerobic	6 hr	13.9	6.3	7.6	1.5	22.7	38.2	190.0	27.1
			End of Settling	8 hr	6.3	6.3	0.0	1.5	23.3	31.2	194.3	27.2
A3	0	0	End of Feeding	2 hr	33.2	19.6	13.6	0.0	0.7	33.9	193.3	49.3
			End of Anaerobic	4 hr	27.0	21.7	5.3	0.0	0.7	27.6	187.6	54.1
			End of Aerobic	6 hr	11.5	6.1	5.4	1.9	22.3	35.7	188.9	29.8
			End of Settling	8 hr	7.3	5.2	2.1	1.7	25.1	34.1	192.0	29.9
B1	60	75	End of Feeding	2 hr	47.5	17.4	30.1	0.0	2.6	50.1	189.0	49.1
			End of Anaerobic	4 hr	32.6	20.0	12.6	0.0	0.7	33.3	180.0	55.7
			End of Aerobic	6 hr	27.0	21.4	5.6	1.4	2.4	30.8	184.5	41.3
			End of Settling	8 hr	29.1	23.0	6.1	1.7	3.0	33.8	193.5	41.6
B2	60	75	End of Feeding	2 hr	39.7	16.7	23.0	0.0	1.2	40.9	181.7	49.9
			End of Anaerobic	4 hr	35.9	20.0	15.8	0.0	0.7	36.6	183.3	56.7
			End of Aerobic	6 hr	27.0	20.6	6.4	0.9	3.9	31.8	187.1	40.8
			End of Settling	8 hr	26.5	22.1	4.3	1.0	4.1	31.6	190.9	40.9
B3	60	75	End of Feeding	2 hr	43.5	16.7	26.7	0.0	0.7	44.1	192.9	52.1
			End of Anaerobic	4 hr	37.6	19.3	18.3	0.0	0.7	38.3	189.5	60.3
			End of Aerobic	6 hr	22.3	20.6	1.7	1.3	2.8	26.3	196.7	46.2
			End of Settling	8 hr	30.5	22.1	8.4	1.1	3.2	34.8	205.5	45.1

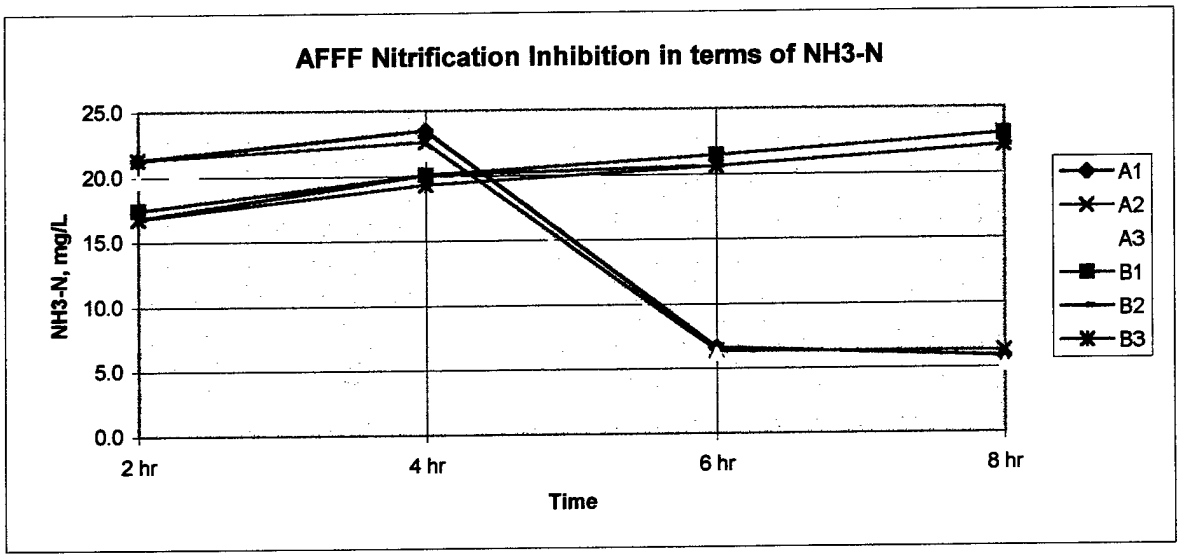
** Values not known

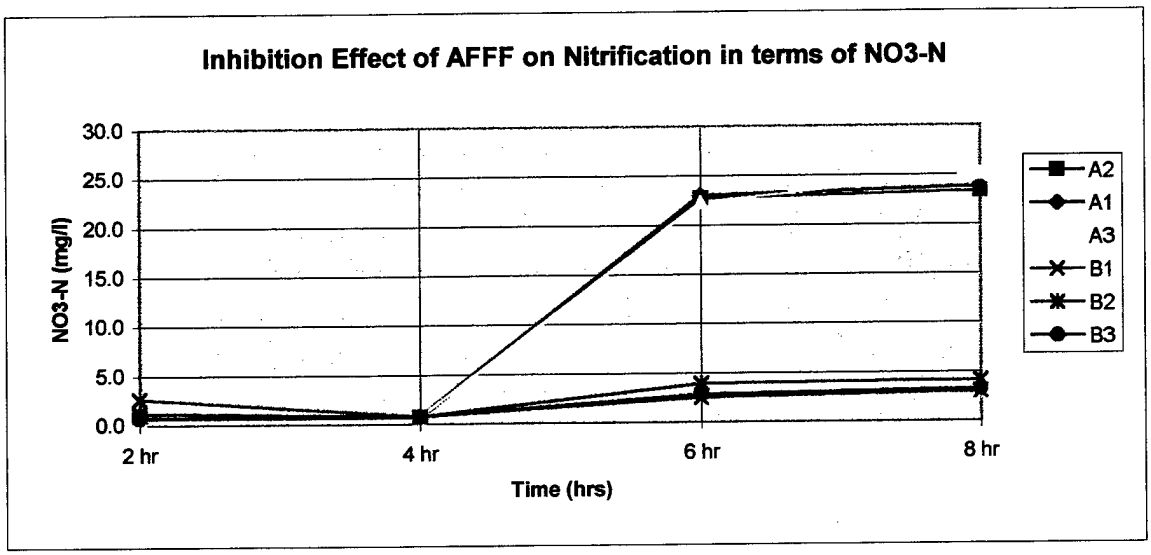
Reactor	AFFF (ppm)	Defoamer 8710 ml/liter	Stage	Time	Concentration, mg/L BOD	COD	TOC	Alkalinity HCO3 (mg/l)
			Feedstock			1189.7	420.0	771.0
			RR Decant			5.9	10.8	333.0
A1	0	0	End of Feeding	2 hr		150.6	19.9	370.0
			End of Anaerobic	4 hr		190.0	15.1	384.0
			End of Aerobic	6 hr		5.9	9.7	207.0
			End of Settling	8 hr		32.2	9.5	216.0
A2	0	0	End of Feeding	2 hr		150.6	20.0	368.0
			End of Anaerobic	4 hr		190.0	14.7	363.0
			End of Aerobic	6 hr		71.6	8.9	227.0
			End of Settling	8 hr		58.5	9.0	214.0
A3	0	0	End of Feeding	2 hr		124.3	20.6	368.0
			End of Anaerobic	4 hr		150.6	14.9	386.0
			End of Aerobic	6 hr		5.9	8.8	219.0
			End of Settling	8 hr		32.2	9.0	213.0
B1	60	75	End of Feeding	2 hr		689.9	149.8	365.0
			End of Anaerobic	4 hr		676.7	147.7	351.0
			End of Aerobic	6 hr		913.5	164.7	350.0
			End of Settling	8 hr		926.7	171.1	294.0
B2	60	75	End of Feeding	2 hr		755.7	145.8	367.0
			End of Anaerobic	4 hr		689.9	148.0	333.0
			End of Aerobic	6 hr		939.8	167.1	344.0
			End of Settling	8 hr		913.5	170.1	327.0
B3	60	75	End of Feeding	2 hr		716.2	151.7	364.0
			End of Anaerobic	4 hr		729.3	146.3	340.0
			End of Aerobic	6 hr		1005.6	173.0	346.0
			End of Settling	8 hr		979.3	173.3	330.0

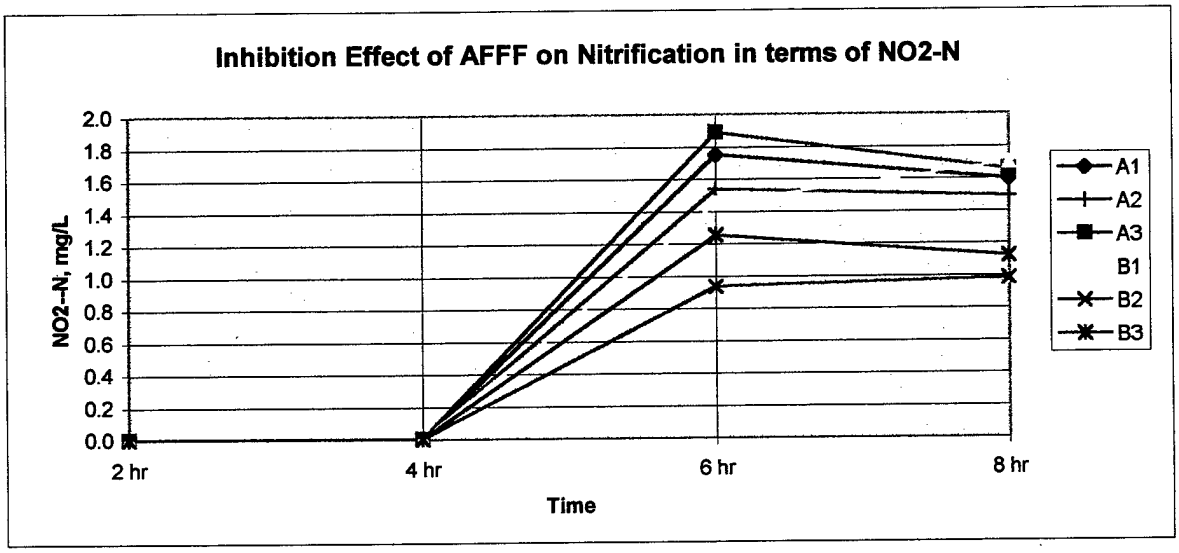


Date of Test: 3-11-97

NH3-N & TKN Charts







A1,A2,A3—Control Reactors B1,B2,B3—Inhibition reactors-->60ppm AFFF with Defoamer 8710

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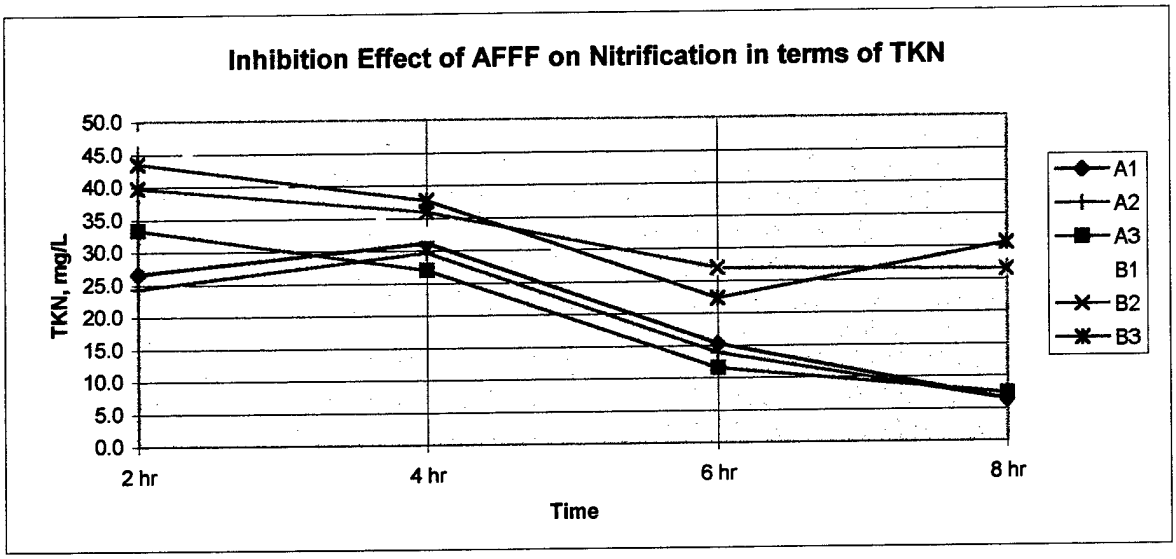
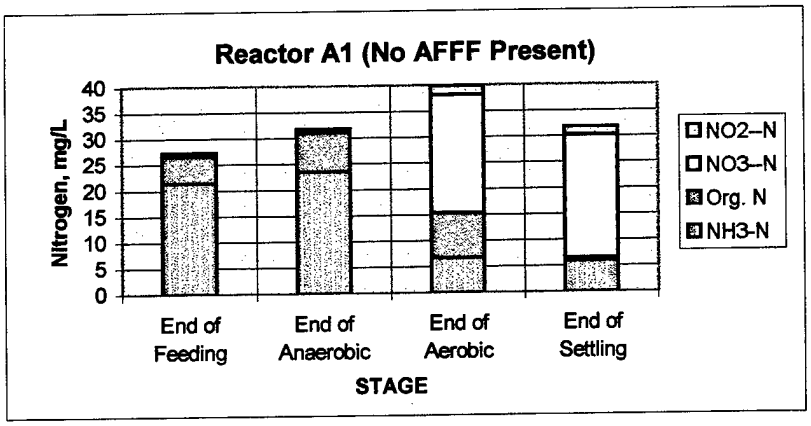
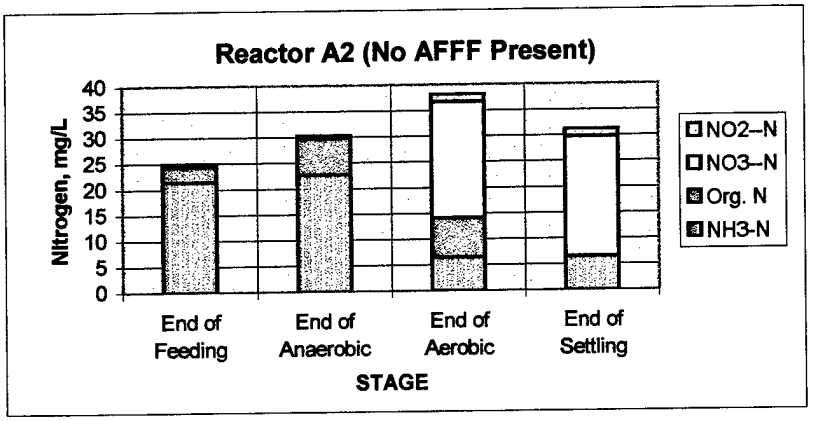
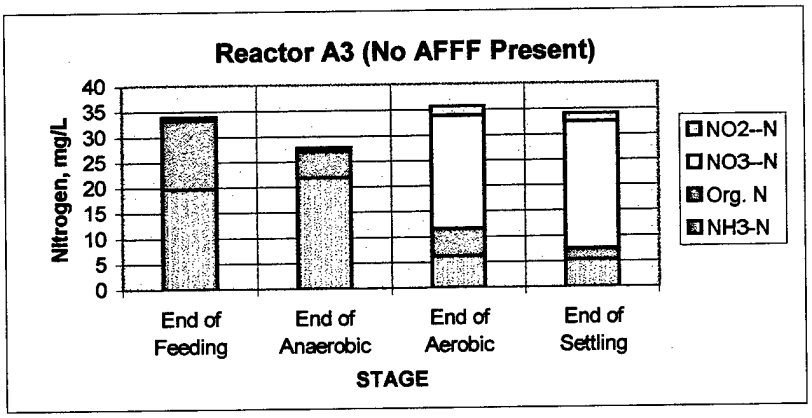
Sheet: NH3-N & TKN Charts

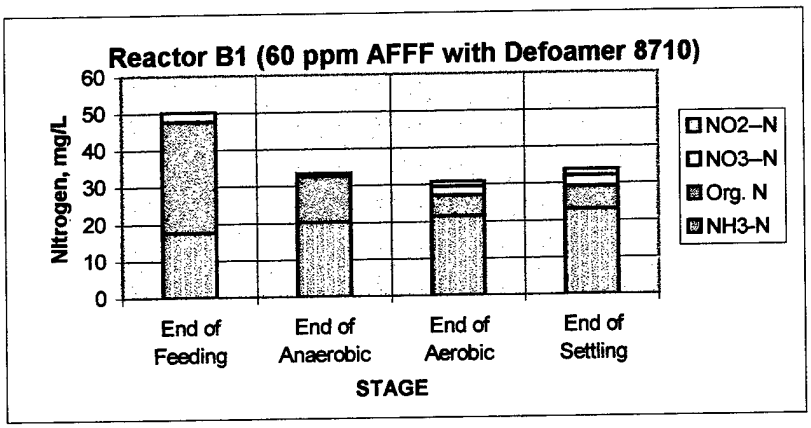


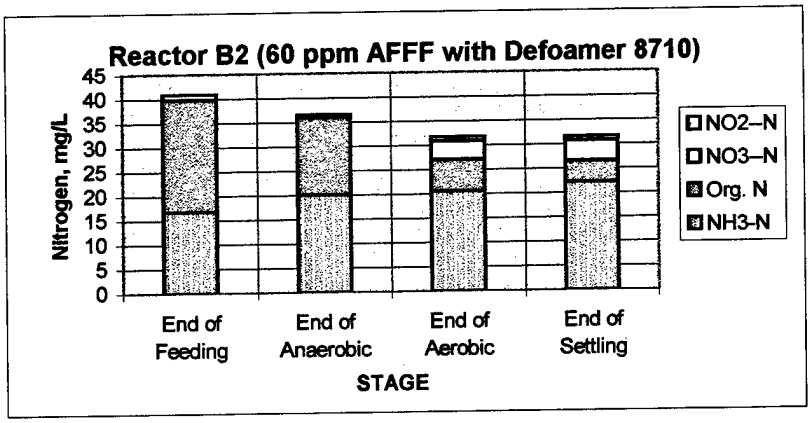
A1,A2,A3—Control Reactors B1,B2,B3—Inhibition reactors-->60ppm AFFF with Defoamer 8710

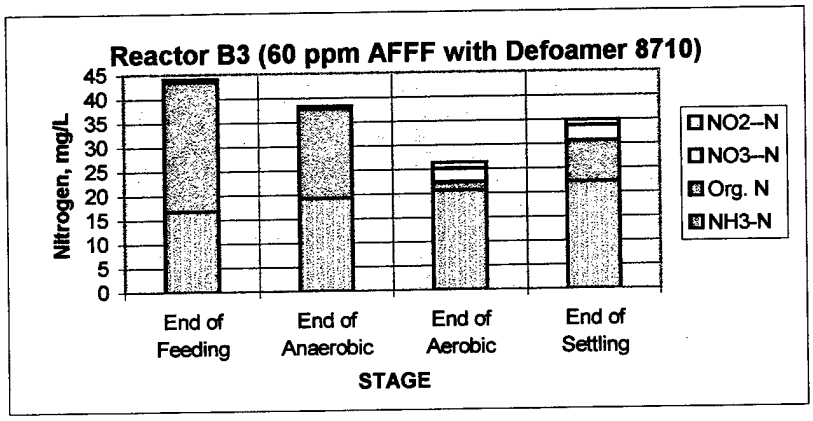

Reactor A1 (No AFFF Present)
Nitrogen, mg/L
40
35
30
25
20
15
10
5
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N


Reactor A2 (No AFFF Present)
Nitrogen, mg/L
40
35
30
25
20
15
10
5
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N

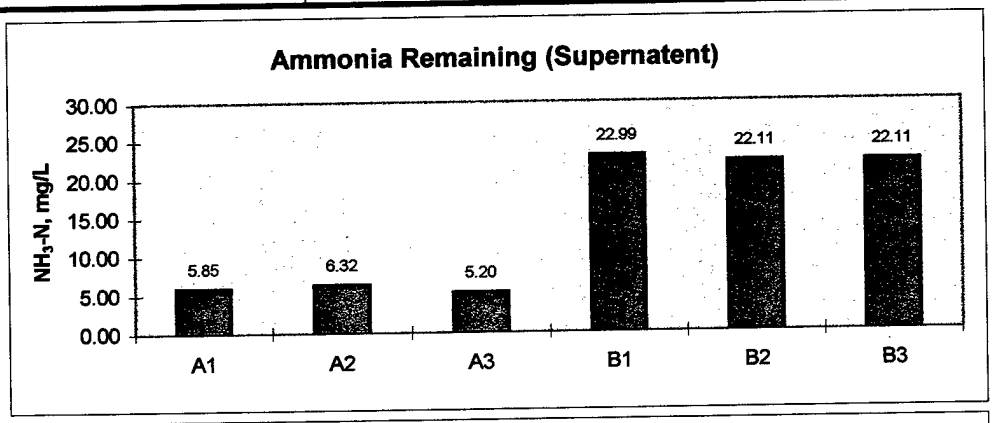

Reactor A3 (No AFFF Present)
Nitrogen, mg/L
40
35
30
25
20
15
10
5
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N

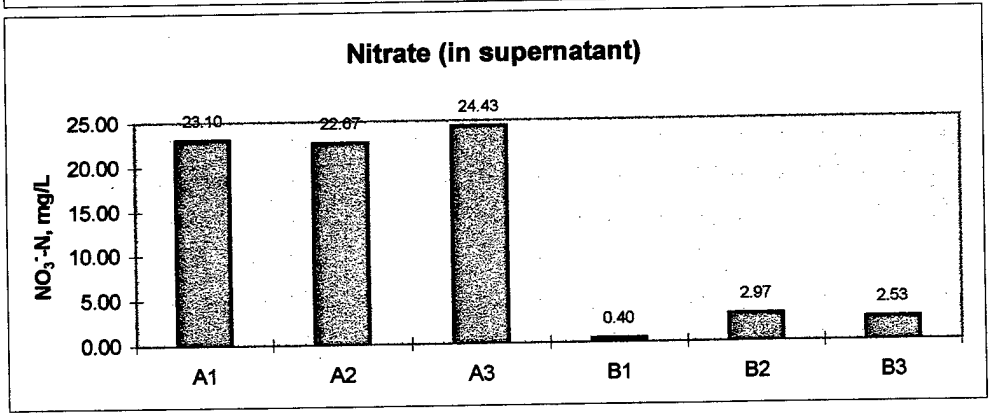

Reactor B1 (60 ppm AFFF with Defoamer 8710)
Nitrogen, mg/L
60
50
40
30
20
10
0
NO2–N
NO3–N
Org. N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE

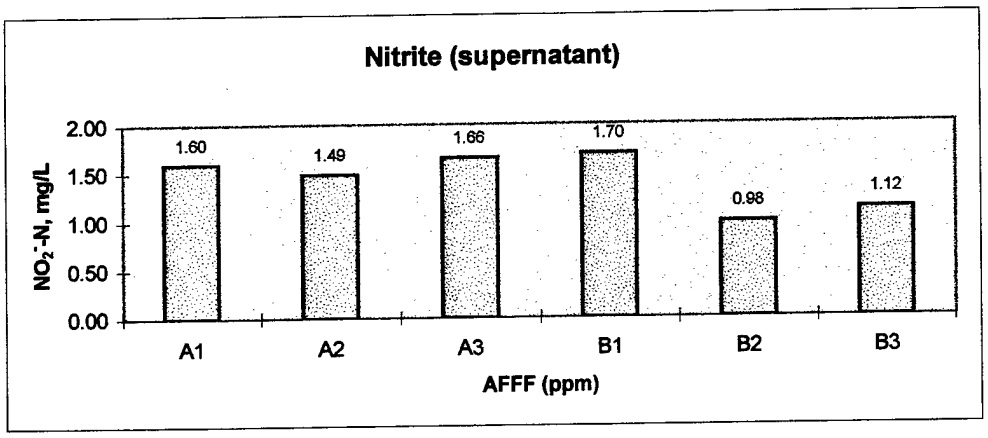

Reactor B2 (60 ppm AFFF with Defoamer 8710)
Nitrogen, mg/L
45
40
35
30
25
20
15
10
5
0
NO2–N
NO3–N
Org. N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE

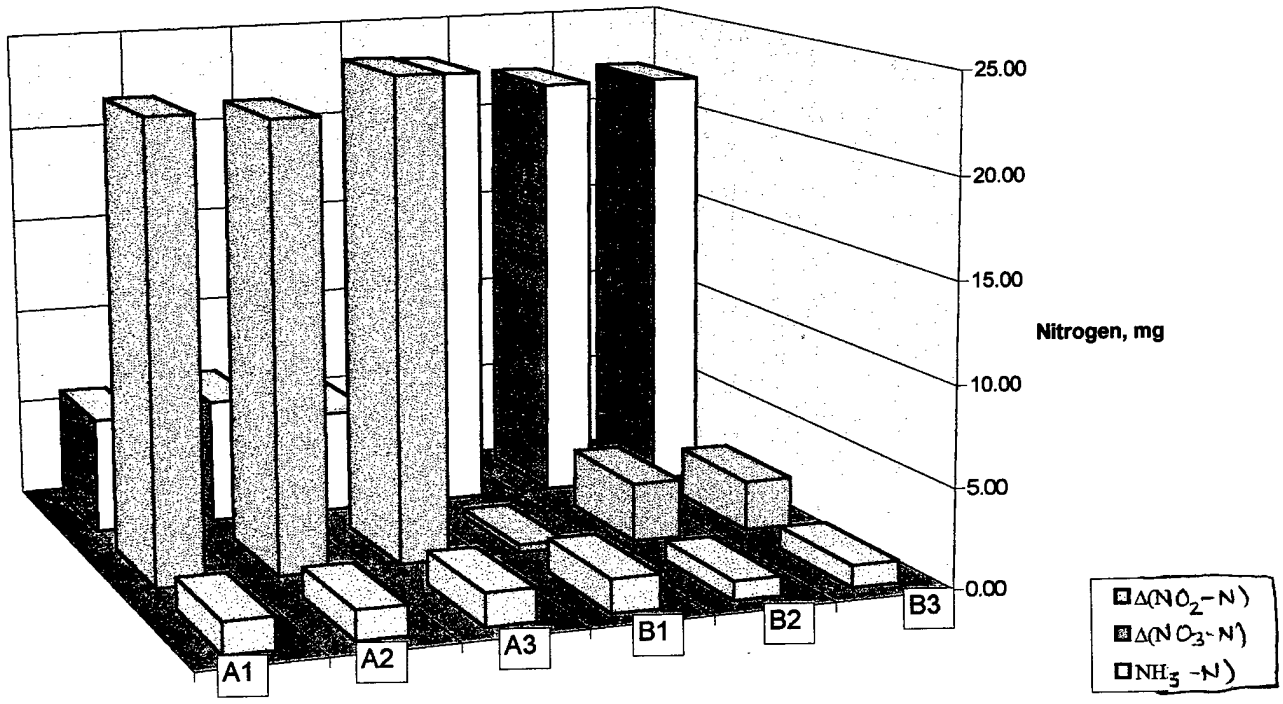

Reactor B3 (60 ppm AFFF with Defoamer 8710)
Nitrogen, mg/L
45
40
35
30
25
20
15
10
5
0
NO2–N
NO3–N
Org. N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE

Reactor	AFFF ppm	Defoamer 8710 ml/liter	Stage	Time	Nitrogen Concentration, mg/L NH3-N	NO3--N	NO2--N	$\Delta(NO_3^-N)$	$\Delta(NO_2^-N)$
A1 (Control)	0	0	End of Feeding	2 hr	21.25	0.7	0.0		
			End of Anaerobic	4 hr	23.46	0.7	0.0		
			End of Aerobic	6 hr	6.59	22.9	1.8		
			End of Settling	8 hr	5.85	23.8	1.6	23.10	1.60
A2 (Control)	0	0	End of Feeding	2 hr	21.25	0.7	0.0		
			End of Anaerobic	4 hr	22.56	0.7	0.0		
			End of Aerobic	6 hr	6.34	22.7	1.5		
			End of Settling	8 hr	6.32	23.3	1.5	22.67	1.49
A3 (Control)	0	0	End of Feeding	2 hr	19.62	0.7	0.0		
			End of Anaerobic	4 hr	21.68	0.7	0.0		
			End of Aerobic	6 hr	6.10	22.3	1.9		
			End of Settling	8 hr	5.20	25.1	1.7	24.43	1.66
B1	60	75	End of Feeding	2 hr	17.41	2.6	0.0		
			End of Anaerobic	4 hr	20.03	0.7	0.0		
			End of Aerobic	6 hr	21.40	2.4	1.4		
			End of Settling	8 hr	22.99	3.0	1.7	0.40	1.70
B2	60	75	End of Feeding	2 hr	16.73	1.2	0.0		
			End of Anaerobic	4 hr	20.03	0.7	0.0		
			End of Aerobic	6 hr	20.58	3.9	0.9		
			End of Settling	8 hr	22.11	4.1	1.0	2.97	0.98
B3	60	75	End of Feeding	2 hr	16.73	0.7	0.0		
			End of Anaerobic	4 hr	19.26	0.7	0.0		
			End of Aerobic	6 hr	20.58	2.8	1.3		
			End of Settling	8 hr	22.11	3.2	1.1	2.53	1.12






Nitrite (supernatant)
2.00
1.50
1.00
0.50
0.00
NO2-N, mg/L
1.60
1.49
1.66
1.70
0.98
1.12
A1
A2
A3
B1
B2
B3
AFFF (ppm)


25.00
20.00
15.00
10.00
5.00
0.00
Nitrogen, mg
A1
A2
A3
B1
B2
B3
Δ(NO2-N)
Δ(NO3-N)
NH3-N)

BNR Inhibition Tests - 60 ppm AFFF Pretreated with Defoamer 8710 (Sept/28/97)

TSS

Reactor	Initial wt	Final wt	Volume	MLSS	WT @ 55	MLVSS
A1	1.0961	1.1459	15	3320	1.1002	3047
A2	1.1036	1.1538	15	3347	1.1084	3027
A3	1.1044	1.1533	15	3260	1.1092	2940
B1	1.1089	1.1674	15	3900	1.1165	3393
B2	1.1127	1.1712	15	3900	1.1202	3400
B3	1.1113	1.167	15	3713	1.1185	3233

TDS

Reactor	Initial wt	Final wt	Volume	TDS
A1	1.025	1.0399	15	993
A2	1.0187	1.0328	15	940
A3	1.0177	~	15	~
B1	1.0219	1.038	15	1073
B2	1.0168	1.0348	15	1200
B3	1.0177	1.0359	15	1213

TS

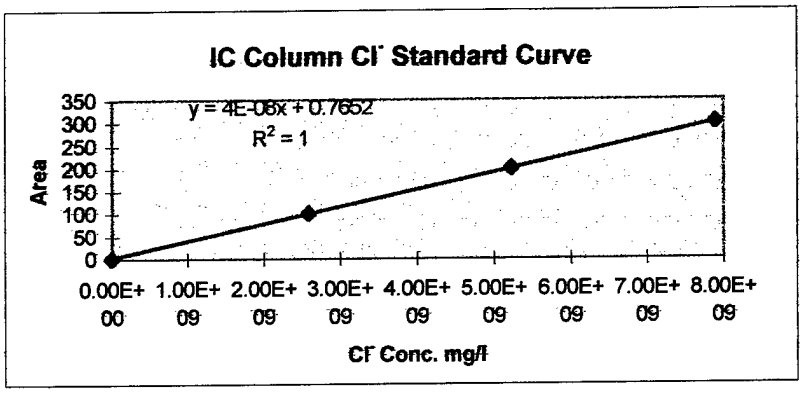
Reactor	Initial wt	Final wt	Volume	TS	ΣTSS,TDS
A1	1.0258	1.0913	15	4367	4313
A2	1.0094	1.0732	15	4253	4287
A3	1.0229	1.0825	15	3973	~
B1	1.0231	1.099	15	5060	4973
B2	1.0271	1.1051	15	5200	5100
B3	1.0198	1.1007	15	5393	4927

BNR Inhibition Batch Assay Pretreated with Defoamer AF9020

(AFFF 60 ppm)

Reactor	AFFF (ppm)	Defoamer AF9020 ml/liter	Stage	Time	NH3-N (mg/L)	TKN (mg/L)	Alkalinity
			Feedstock		26.7	25.7	433.0
			RR Decant		0.1	1.6	326.0
A1	0	0	End of Feeding	2 hr	24.6	17.8	534.0
			End of Anaerobic	4 hr	30.0	41.1	527.0
			End of Aerobic	6 hr	4.7	14.4	357.0
			End of Settling	8 hr	2.8	14.4	350.0
A2	0	0	End of Feeding	2 hr	24.0	14.4	540.0
			End of Anaerobic	4 hr	29.4	43.3	528.0
			End of Aerobic	6 hr	4.5	18.7	355.0
			End of Settling	8 hr	3.2	11.1	340.0
A3	0	0	End of Feeding	2 hr	25.7	15.2	511.0
			End of Anaerobic	4 hr	31.0	45.6	524.0
			End of Aerobic	6 hr	3.2	16.0	354.0
			End of Settling	8 hr	2.8	10.5	350.0
B1	60	15	End of Feeding	2 hr	22.3	20.8	507.0
			End of Anaerobic	4 hr	28.9	59.3	511.0
			End of Aerobic	6 hr	10.7	25.7	381.0
			End of Settling	8 hr	11.3	19.7	400.0
B2	60	15	End of Feeding	2 hr	23.5	28.5	493.0
			End of Anaerobic	4 hr	30.3	53.4	516.0
			End of Aerobic	6 hr	11.9	27.0	407.0
			End of Settling	8 hr	13.2	27.0	400.0
B3	60	15	End of Feeding	2 hr	21.4	27.0	510.0
			End of Anaerobic	4 hr	30.3	56.2	531.0
			End of Aerobic	6 hr	12.6	27.0	447.0
			End of Settling	8 hr	15.4	28.5	417.0

		Defoamer										
	AFFF	AF 9020			Cl-		NO_2^--N		NO_3^--N		PO4-P	
Reactor	(ppm)	ml/liter	Stage	Time	Area	(mg/L)	Area	(mg/L)	Area	(mg/L)	Absorb.	mg/l
			Feedstock		7458784718	283.8	0	0.0	6230008	0.9	1.612	47.89
			RR Decant		6215776781	236.7	0	0.0	1461239493	24.3	0.019	-1.24
A1	0	0	End of Feeding	2 hr	6521436722	248.3	0	0.0	1225112	0.8	0.56	15.45
			End of Anaerobic	4 hr	6541737522	249.0	0	0.0	206220	0.8	0.607	16.90
			End of Aerobic	6 hr	6526328166	248.4	142391549	2.9	1158812851	19.4	0.149	2.77
			End of Settling	8 hr	6628917720	252.3	153197095	3.1	1131344921	19.0	0.17	3.42
A2	0	0	End of Feeding	2 hr	6496185022	247.3	0	0.0	3020068	0.8	0.48	12.98
			End of Anaerobic	4 hr	6493904107	247.2	0	0.0	0	0.8	0.49	13.29
			End of Aerobic	6 hr	6607957850	251.5	157637708	3.2	1116272031	18.7	0.039	-0.62
			End of Settling	8 hr	6559750264	249.7	147310900	3.0	1329426657	22.1	0.151	2.83
A3	0	0	End of Feeding	2 hr	6462688484	246.0	0	0.0	0	0.8	0.639	17.88
			End of Anaerobic	4 hr	6541325694	249.0	0	0.0	15585084	1.0	0.693	19.55
			End of Aerobic	6 hr	6537345571	248.9	166524849	3.4	1194876061	20.0	0.184	3.85
			End of Settling	8 hr	6696567822	254.9	148840324	3.0	1007475791	17.0	0.252	5.95
B1	60	15	End of Feeding	2 hr	6379079984	242.9	0	0.0	156248	0.8	0.725	20.54
			End of Anaerobic	4 hr	6384157598	243.0	0	0.0	105106	0.8	0.905	26.09
			End of Aerobic	6 hr	6408351115	244.0	145107540	2.9	635447762	11.0	0.257	6.10
			End of Settling	8 hr	6738146973	256.5	126417813	2.5	793675421	13.5	0.467	12.58
B2	60	15	End of Feeding	2 hr	6373314182	242.6	0	0.0	0	0.8	0.889	25.60
			End of Anaerobic	4 hr	6446545211	245.4	0	0.0	96884	0.8	1.236	36.30
			End of Aerobic	6 hr	6207893047	236.4	121298643	2.4	280948060	5.3	0.128	2.12
			End of Settling	8 hr	6626744880	252.3	134009389	2.7	514120835	9.0	0.616	17.18
B3	60	15	End of Feeding	2 hr	6391628940	243.3	0	0.0	145740	0.8	0.903	26.03
			End of Anaerobic	4 hr	6401156329	243.7	0	0.0	0	0.8	1.495	44.29
			End of Aerobic	6 hr	6568896471	250.1	109336485	2.1	293674209	5.5	0.514	14.03
			End of Settling	8 hr	6532740605	248.7	131553129	2.6	809881753	13.8	0.301	7.46
			Stand 3		5219091409	198.8	917655285	20.7	1148516754	19.2		
			Standards used									
			STD 1		472916	0	0	0	1293424	0	0.185	5
			STD 2		2592013444	100	454327901	10	537513653	10	0.756	20
			STD 3		5234110314	200	925169445	20	1154945353	20	1.217	35
			STD 4		7902689639	300	1738139936	40	2467096565	40	1.645	50



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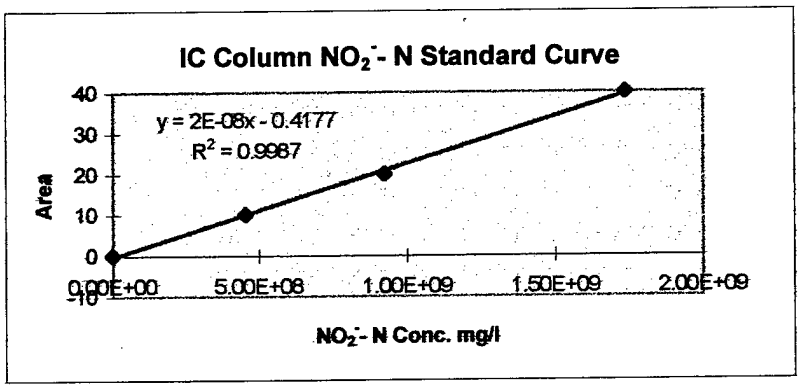

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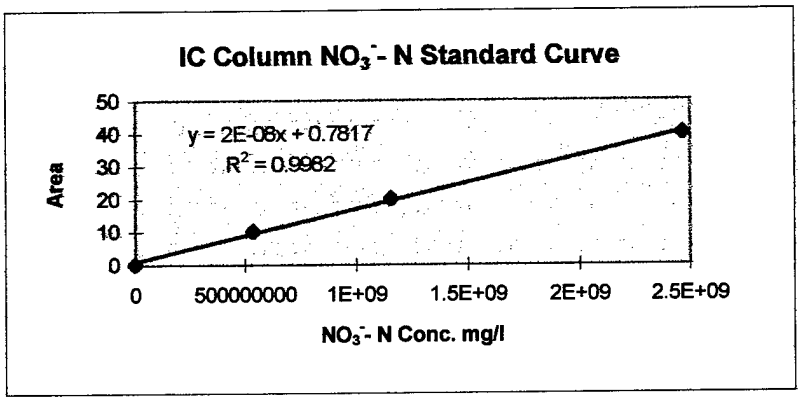

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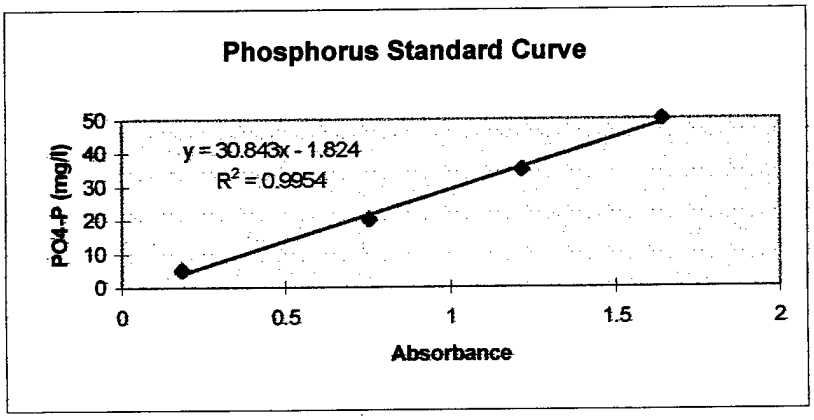


SUMMARY OUTPUT

CL

Regression Statistics	
R Square	0.99995642
Observations	4

	Coefficients	*Standard Error*
Intercept	0.76519136	0.870412079
X Variable 1	3.7951E-08	1.7715E-10

SUMMARY OUTPUT

NO2-N

Regression Statistics	
R Square	0.99873067
Observations	4

	Coefficients	*Standard Error*
Intercept	-0.41772585	0.585531826
X Variable 1	2.2989E-08	5.79516E-10

SUMMARY OUTPUT

NO3-N

Regression Statistics	
R Square	0.99817439
Observations	4

	Coefficients	*Standard Error*
Intercept	0.7816875	0.674739918
X Variable 1	1.6072E-08	4.86023E-10

SUMMARY OUTPUT

PO4-P

Regression Statistics	
R Square	0.99540535
Observations	4

	Coefficients	*Standard Error*
Intercept	-1.82395065	1.621942917
X Variable 1	30.8429668	1.481724664

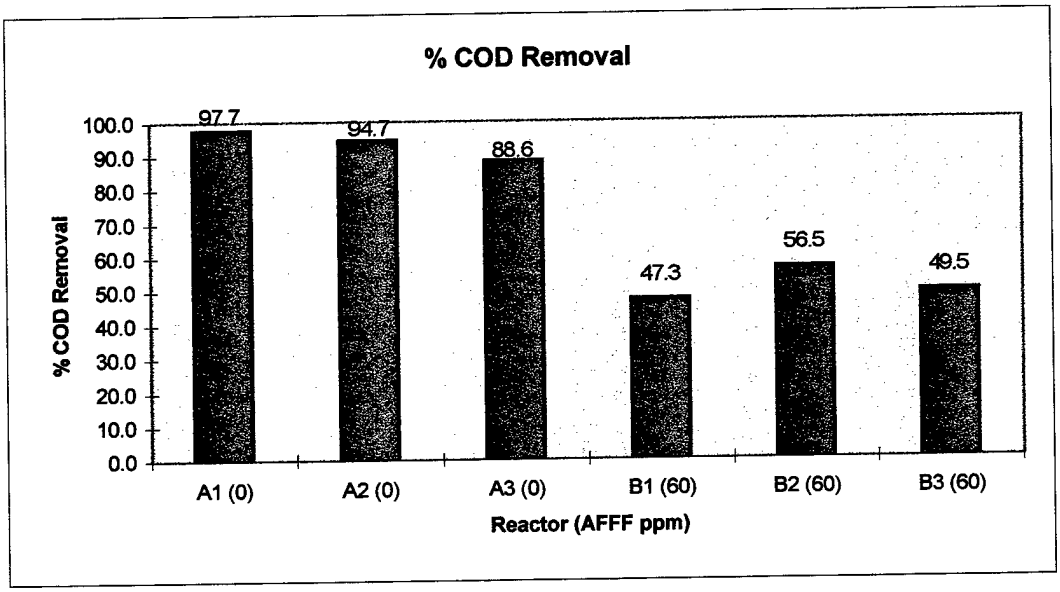
Reactor	AFFF (ppm)	Defoamer AF9020 ml/liter	Stage	Time	COD ABS	COD (mg/L)	COD % COD Removal*
			Feedstock		0.087	**1125.0**	
			RR Decant		0.011	**104.3**	
A1	0	0	End of Feeding	2 hr	0.014	**144.6**	67.5
			End of Anaerobic	4 hr	0.013	**131.2**	70.5
			End of Aerobic	6 hr	0.006	**37.1**	91.6
			End of Settling	8 hr	0.004	**10.3**	**97.7**
A2	0	0	End of Feeding	2 hr	0.014	**144.6**	67.5
			End of Anaerobic	4 hr	0.014	**144.6**	67.5
			End of Aerobic	6 hr	0.004	**10.3**	97.7
			End of Settling	8 hr	0.005	**23.7**	**94.7**
A3	0	0	End of Feeding	2 hr	0.012	**117.7**	73.5
			End of Anaerobic	4 hr	0.010	**90.9**	79.6
			End of Aerobic	6 hr	0.008	**64.0**	85.6
			End of Settling	8 hr	0.007	**50.6**	**88.6**
B1	60	15	End of Feeding	2 hr	0.061	**775.8**	59.3
			End of Anaerobic	4 hr	0.057	**722.1**	62.1
			End of Aerobic	6 hr	0.065	**829.5**	56.5
			End of Settling	8 hr	0.078	**1004.1**	**47.3**
B2	60	15	End of Feeding	2 hr	0.067	**856.4**	55.1
			End of Anaerobic	4 hr	0.058	**735.5**	61.4
			End of Aerobic	6 hr	0.059	**748.9**	60.7
			End of Settling	8 hr	0.065	**829.5**	**56.5**
B3	60	15	End of Feeding	2 hr	0.061	**775.8**	59.3
			End of Anaerobic	4 hr	0.059	**748.9**	60.7
			End of Aerobic	6 hr	0.064	**816.1**	57.2
			End of Settling	8 hr	0.075	**963.8**	**49.5**
			STD 1		0.000	0	
			STD 2		0.083	1000	
			STD 3		0.153	2000	
			STD 4		0.223	3000	
			STD 5		0.339	4500	
			FS (Filtered)		0.087	1096.0	
			FS Average		**0.087**	**1096.0**	
			RRSU(Filtered)		0.011	59.3	
			RRSU Average		**0.011**	**59.3**	

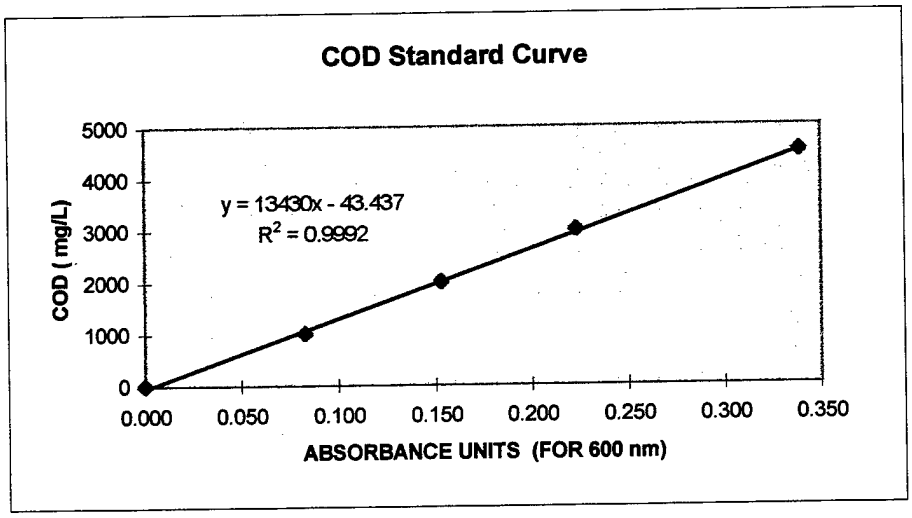
* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.

Initial COD at Time 0 hr.

Sample	Constituent	Vol (L)	COD mg/L	
Controls	RR Decant	4	104.3	417.172
(A1,A2&A3)	Feedstock	2	1125.0	2249.946
	Defoamer	2	0	0
	AFFF	0	0	0
	Total	6		**444.5**
Inhibition	RR Decant	4	104.3	417.172
(B1,B2&B3)	Feedstock	2	1125.0	2249.946
	Defoamer	1	5300	5300
	AFFF	2	1737	3474
	Total	6		**1906.9**

Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (60)	B2 (60)	B3 (60)
% COD Removal	97.7	94.7	88.6	47.3	56.5	49.5





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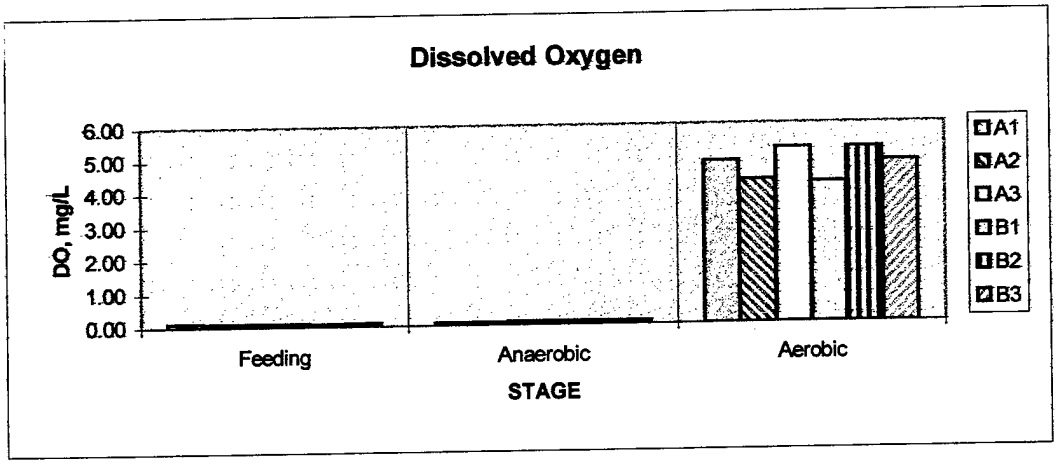
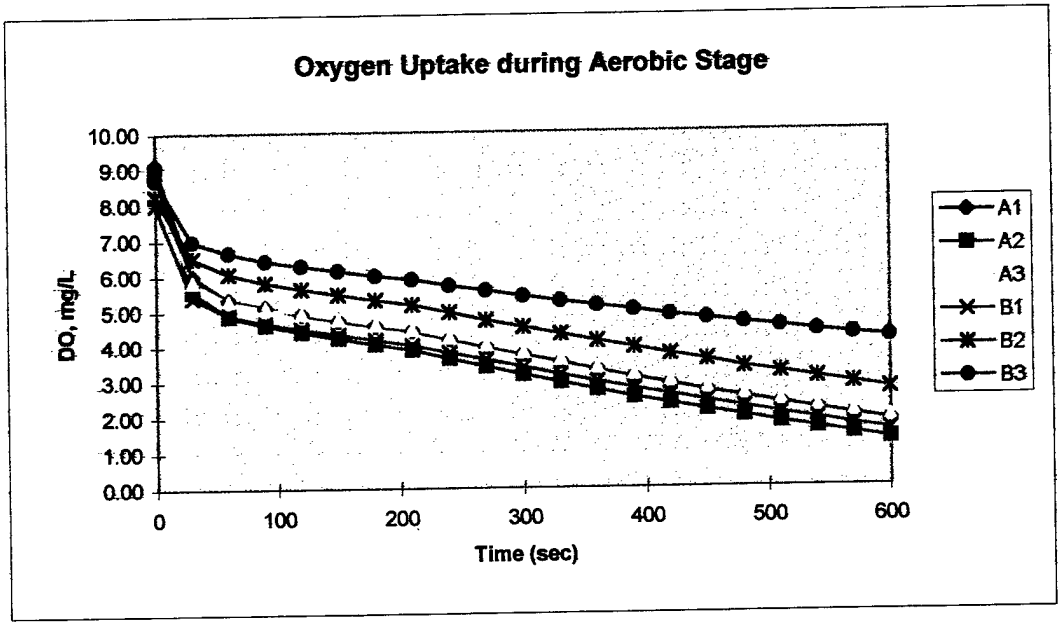

Dissolved Oxygen
DO, mg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3


Oxygen Uptake during Aerobic Stage
DO, mg/L
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
100
200
300
400
500
600
Time (sec)
A1
A2
A3
B1
B2
B3

Stage	Dissolved Oxygen (mg/L) at various stages					
	A1	A2	A3	B1	B2	B3
Feeding	0.11	0.09	0.09	0.09	0.08	0.10
Anaerobic	0.07	0.08	0.09	0.09	0.10	0.09
Aerobic	4.88	4.30	5.27	4.21	5.27	4.85

Stage	Time (sec)	Dissolved Oxygen in mg/L					
		A1	A2	A3	B1	B2	B3
Aerobic	0	9.12	8.92	8.28	8.00	8.24	8.69
	30	5.98	5.54	5.83	5.38	6.49	6.96
	60	5.32	4.85	5.28	4.88	6.04	6.64
	90	5.09	4.59	5.08	4.66	5.80	6.40
	120	4.91	4.40	4.92	4.49	5.61	6.26
	150	4.73	4.23	4.76	4.33	5.45	6.11
	180	4.57	4.05	4.60	4.16	5.29	5.98
	210	4.41	3.88	4.46	4.01	5.15	5.86
	240	4.17	3.63	4.23	3.80	4.93	5.69
	270	3.95	3.40	4.01	3.59	4.71	5.54
	300	3.73	3.17	3.79	3.38	4.51	5.39
	330	3.52	2.95	3.59	3.17	4.31	5.25
	360	3.31	2.74	3.37	2.97	4.12	5.12
	390	3.10	2.53	3.17	2.77	3.93	4.99
	420	2.89	2.34	2.97	2.59	3.74	4.85
	450	2.71	2.16	2.78	2.41	3.58	4.74
	480	2.52	1.98	2.59	2.23	3.36	4.62
	510	2.34	1.81	2.41	2.06	3.22	4.50
	540	2.18	1.65	2.24	1.89	3.06	4.39
	570	2.01	1.49	2.08	1.72	2.90	4.28
	600	1.85	1.33	1.92	1.57	2.74	4.18

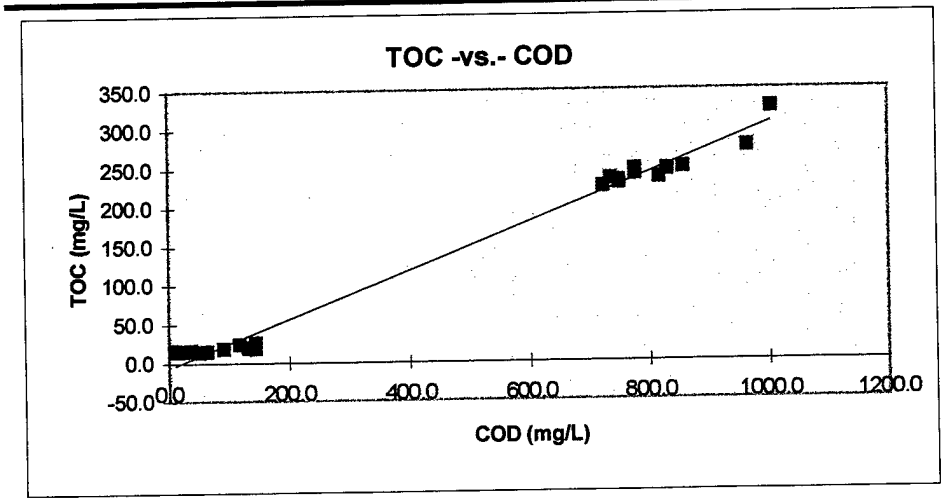
Reactor	AFFF (ppm)	Defoamer AF9020 ml/liter	Stage	Time	Concentration, mg/L TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
			Feedstock		25.7	26.7	-1.0	0.0	0.9	26.5	283.8	47.9
			RR Decant		1.6	0.1	1.5	0.0	24.3	25.8	236.7	-1.2
A1	0	0	End of Feeding	2 hr	17.8	24.6	-6.8	0.0	0.8	18.6	248.3	15.4
			End of Anaerobic	4 hr	41.1	30.0	11.1	0.0	0.8	41.9	249.0	16.9
			End of Aerobic	6 hr	14.4	4.7	9.8	2.9	19.4	36.7	248.4	2.8
			End of Settling	8 hr	14.4	2.8	11.6	3.1	19.0	36.5	252.3	3.4
A2	0	0	End of Feeding	2 hr	14.4	24.0	-9.6	0.0	0.8	15.3	247.3	13.0
			End of Anaerobic	4 hr	43.3	29.4	13.9	0.0	0.8	44.1	247.2	13.3
			End of Aerobic	6 hr	18.7	4.5	14.3	3.2	18.7	40.7	251.5	-0.6
			End of Settling	8 hr	11.1	3.2	8.0	3.0	22.1	36.2	249.7	2.8
A3	0	0	End of Feeding	2 hr	15.2	25.7	-10.5	0.0	0.8	16.0	246.0	17.9
			End of Anaerobic	4 hr	45.6	31.0	14.6	0.0	1.0	46.6	249.0	19.6
			End of Aerobic	6 hr	16.0	3.2	12.8	3.4	20.0	39.4	248.9	3.9
			End of Settling	8 hr	10.5	2.8	7.8	3.0	17.0	30.5	254.9	5.9
B1	60	15	End of Feeding	2 hr	20.8	22.3	-1.5	0.0	0.8	21.6	242.9	20.5
			End of Anaerobic	4 hr	59.3	28.9	30.4	0.0	0.8	60.0	243.0	26.1
			End of Aerobic	6 hr	25.7	10.7	14.9	2.9	11.0	39.6	244.0	6.1
			End of Settling	8 hr	19.7	11.3	8.5	2.5	13.5	35.8	256.5	12.6
B2	60	15	End of Feeding	2 hr	28.5	23.5	5.0	0.0	0.8	29.3	242.6	25.6
			End of Anaerobic	4 hr	53.4	30.3	23.1	0.0	0.8	54.2	245.4	36.3
			End of Aerobic	6 hr	27.0	11.9	15.2	2.4	5.3	34.7	236.4	2.1
			End of Settling	8 hr	27.0	13.2	13.8	2.7	9.0	38.7	252.3	17.2
B3	60	15	End of Feeding	2 hr	27.0	21.4	5.7	0.0	0.8	27.8	243.3	26.0
			End of Anaerobic	4 hr	56.2	30.3	26.0	0.0	0.8	57.0	243.7	44.3
			End of Aerobic	6 hr	27.0	12.6	14.5	2.1	5.5	34.6	250.1	14.0
			End of Settling	8 hr	28.5	15.4	13.1	2.6	13.8	44.9	248.7	7.5

Date of Test: 3-25-97

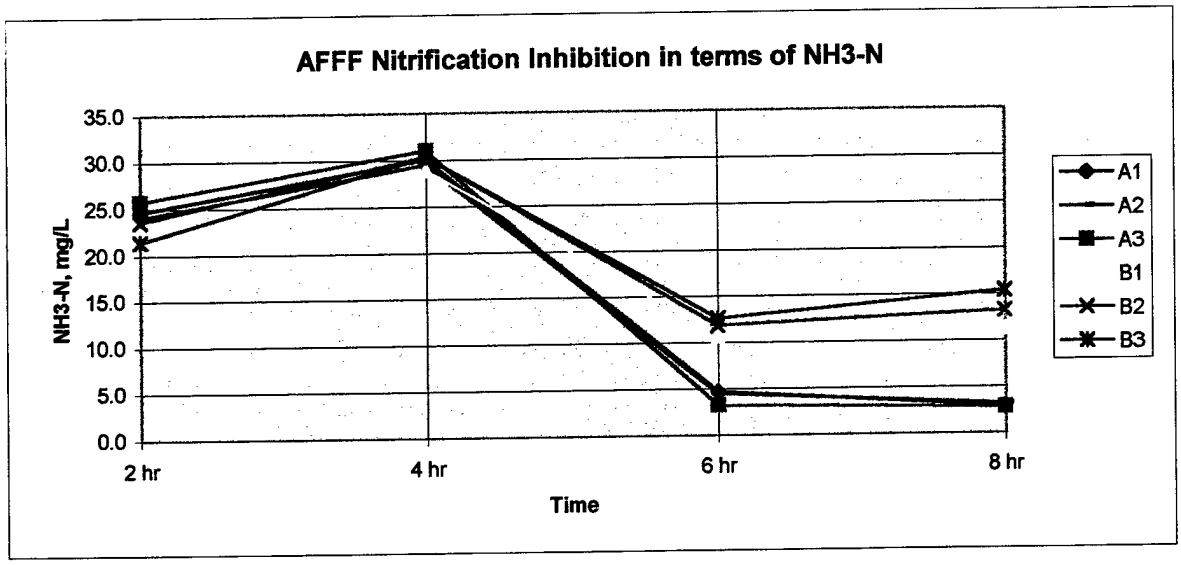
Concentrations Table

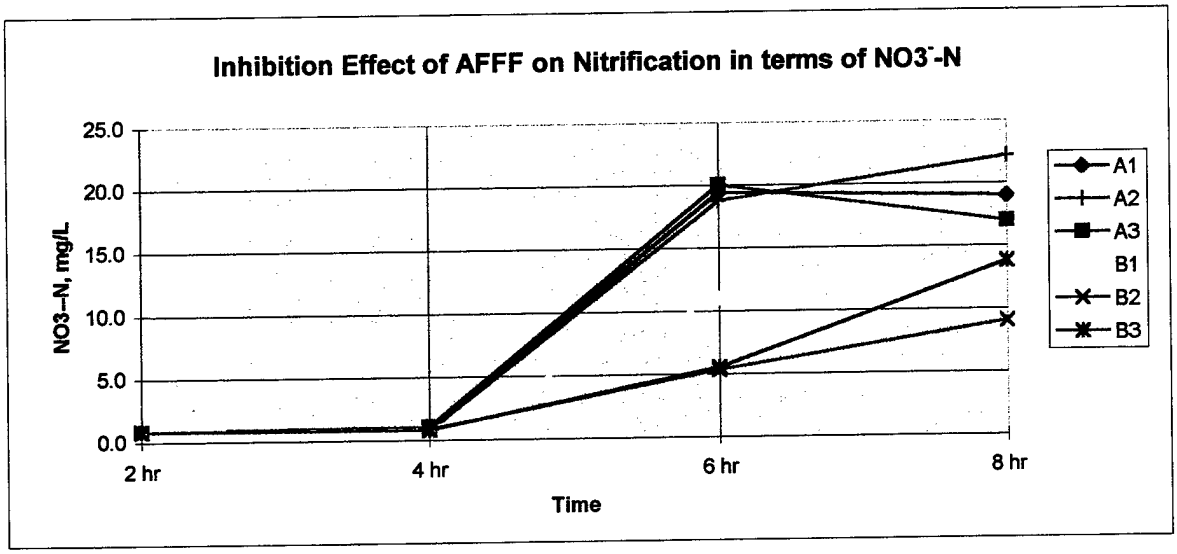
AFFF Conc. = 60 ppm

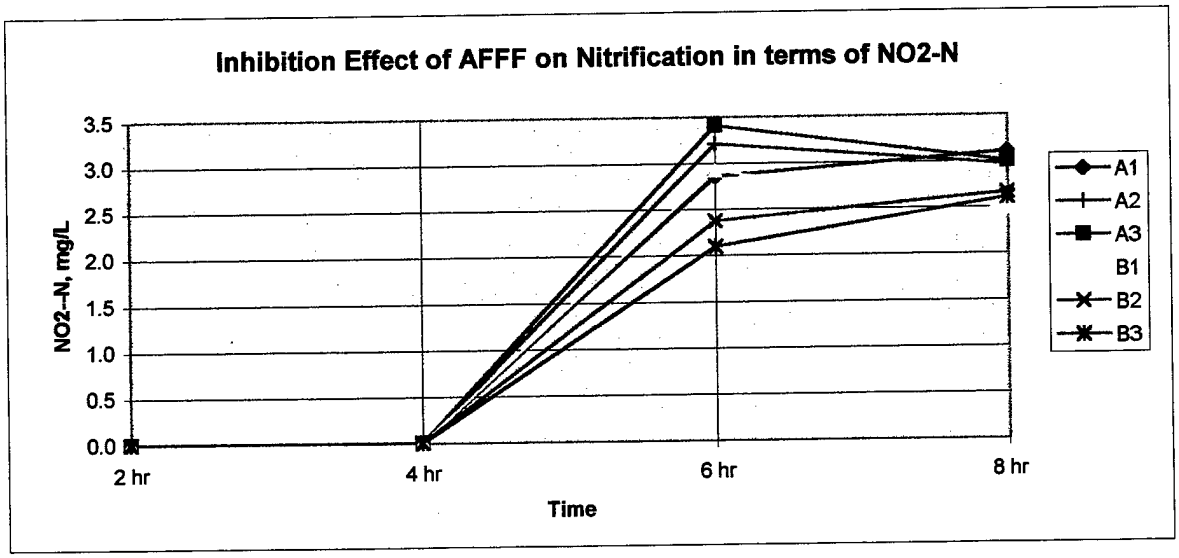
Reactor	AFFF (ppm)	Stage	Time	Concentration, mg/L BOD	COD	TOC	Alkalinity HCO3 (mg/l)
		Feedstock			1125.0	443.1	433.0
		RR Decant			104.3	13.9	326.0
A1	0	End of Feeding	2 hr		144.6	**25.4**	534.0
		End of Anaerobic	4 hr		131.2	**19.1**	527.0
		End of Aerobic	6 hr		37.1	**15.2**	357.0
		End of Settling	8 hr		10.3	**15.3**	350.0
A2	0	End of Feeding	2 hr		144.6	**25.4**	540.0
		End of Anaerobic	4 hr		144.6	**18.3**	528.0
		End of Aerobic	6 hr		10.3	**14.4**	355.0
		End of Settling	8 hr		23.7	**14.4**	340.0
A3	0	End of Feeding	2 hr		117.7	**24.0**	511.0
		End of Anaerobic	4 hr		90.9	**17.7**	524.0
		End of Aerobic	6 hr		64.0	**14.4**	354.0
		End of Settling	8 hr		50.6	**14.2**	350.0
B1	60	End of Feeding	2 hr		775.8	**241.1**	507.0
		End of Anaerobic	4 hr		722.1	**225.9**	511.0
		End of Aerobic	6 hr		829.5	**247.5**	381.0
		End of Settling	8 hr		1004.1	**326.0**	400.0
B2	60	End of Feeding	2 hr		856.4	**249.6**	493.0
		End of Anaerobic	4 hr		735.5	**235.8**	516.0
		End of Aerobic	6 hr		748.9	**232.6**	407.0
		End of Settling	8 hr		829.5	**246.2**	400.0
B3	60	End of Feeding	2 hr		775.8	**247.4**	510.0
		End of Anaerobic	4 hr		748.9	**229.4**	531.0
		End of Aerobic	6 hr		816.1	**236.2**	447.0
		End of Settling	8 hr		963.8	**276.4**	417.0
		FS1				444.1	
		FS2				443.6	
		FS3				441.5	
		FS Avarage				443.1	
		RRSU1				14.7	
		RRSU2				13.5	
		RRSU3				13.3	
		RRSU Avarage				13.87	

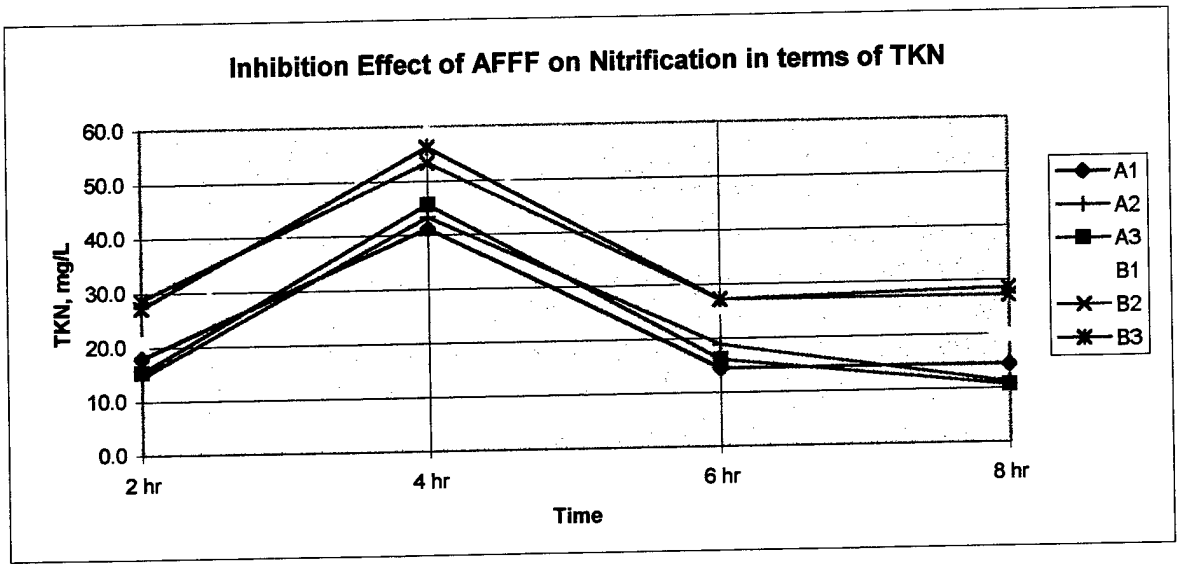


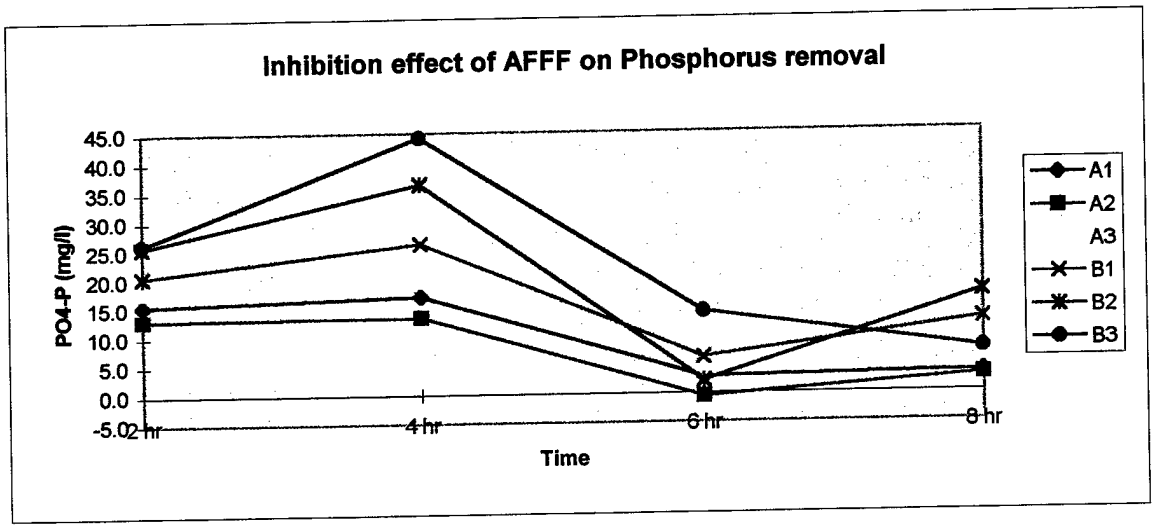
File: AFFF Inhib (2-11-97).xls
Sheet: Concentrations Table

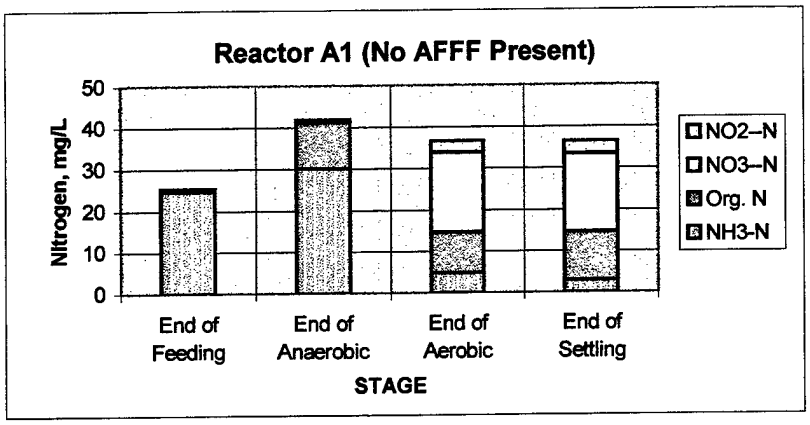

AFFF Nitrification Inhibition in terms of NH3-N
NH3-N, mg/L
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

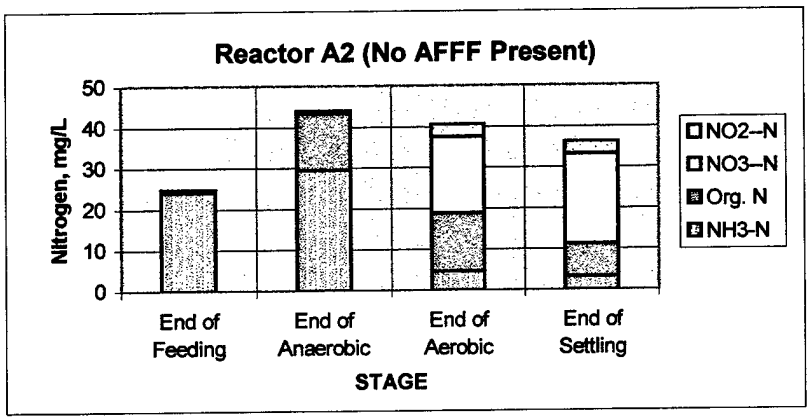

Inhibition Effect of AFFF on Nitrification in terms of NO3-N
NO3--N, mg/L
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

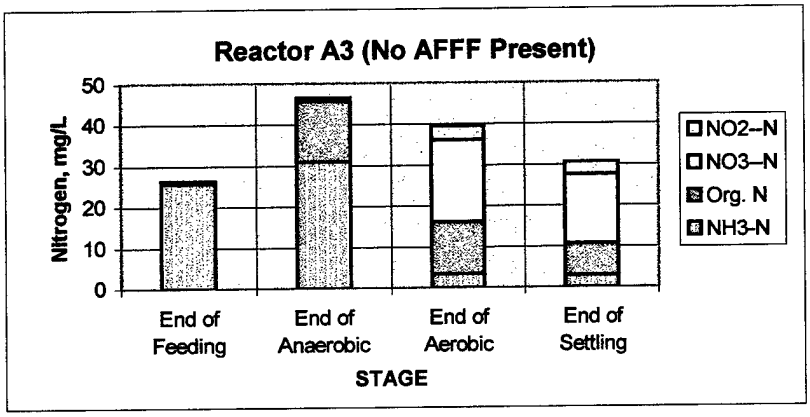

Inhibition Effect of AFFF on Nitrification in terms of NO2-N
NO2--N, mg/L
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

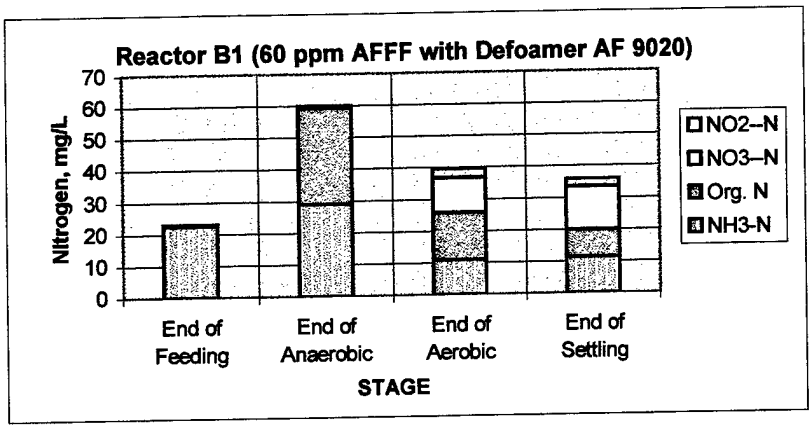

Inhibition Effect of AFFF on Nitrification in terms of TKN
TKN, mg/L
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

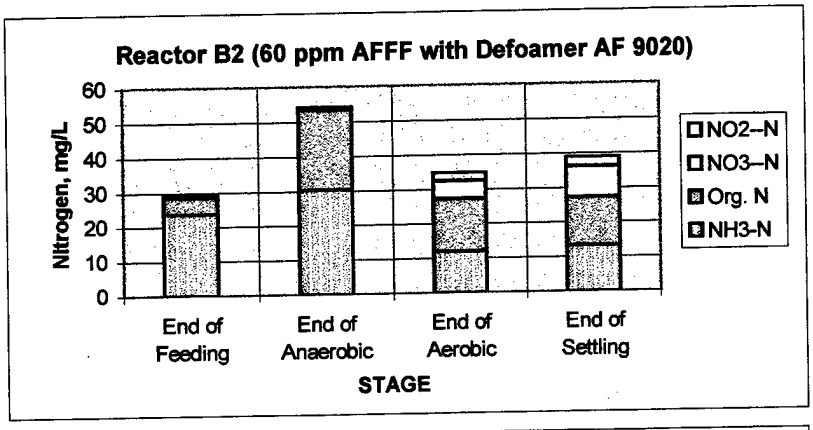

Inhibition effect of AFFF on Phosphorus removal
PO4-P (mg/l)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

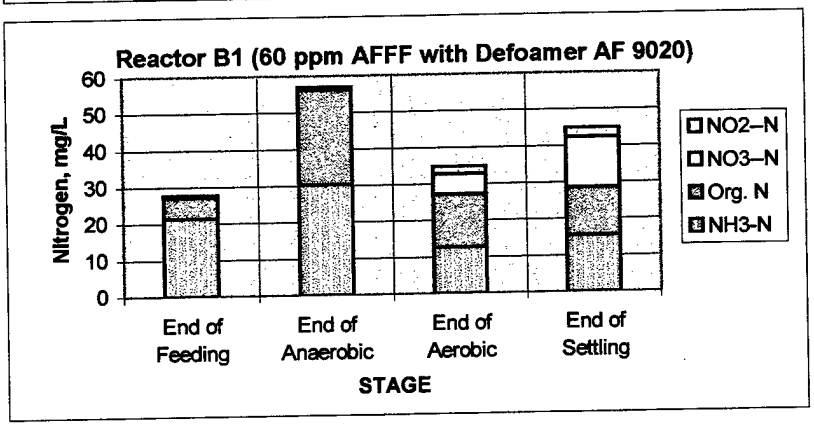

Reactor A1 (No AFFF Present)
Nitrogen, mg/L
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N


Reactor A2 (No AFFF Present)
Nitrogen, mg/L
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N

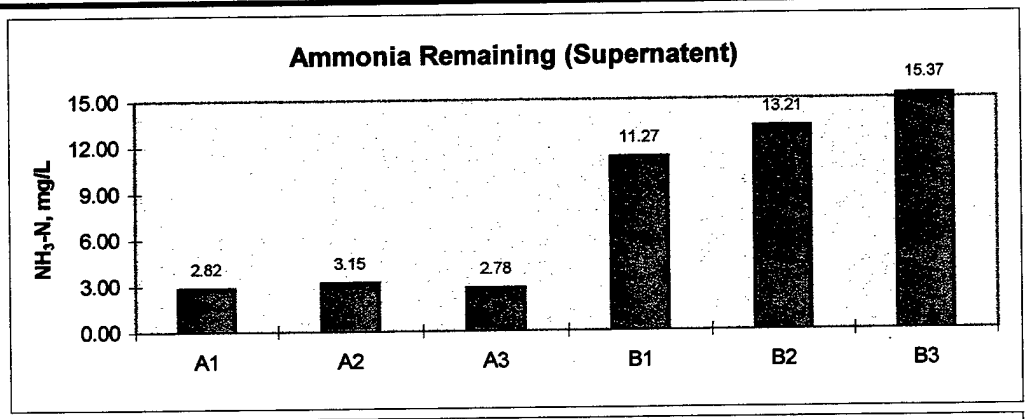

Reactor A3 (No AFFF Present)
Nitrogen, mg/L
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N

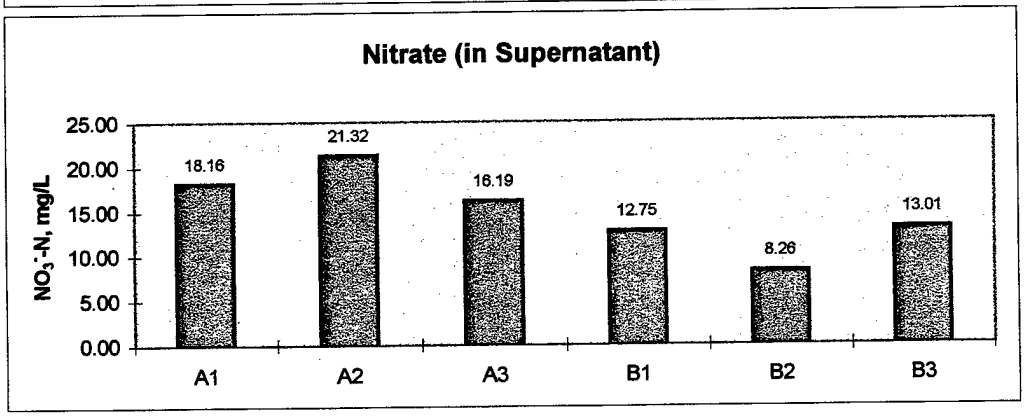

Reactor B1 (60 ppm AFFF with Defoamer AF 9020)
Nitrogen, mg/L
70
60
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N

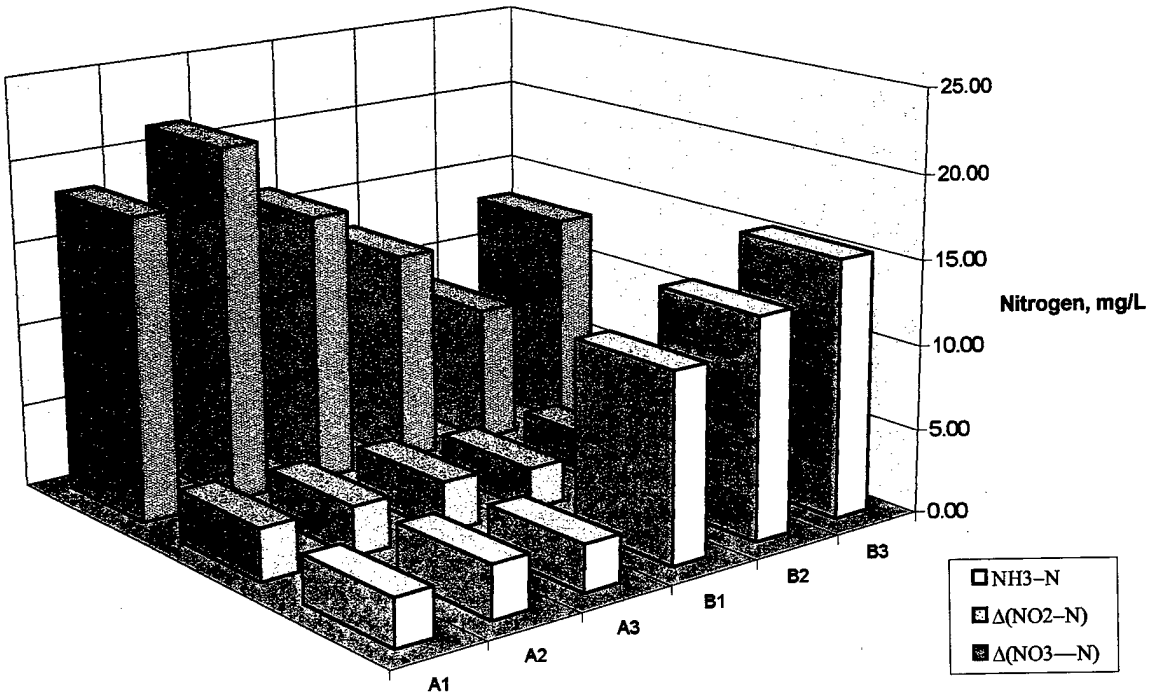

Reactor B2 (60 ppm AFFF with Defoamer AF 9020)
Nitrogen, mg/L
60
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N


Reactor B1 (60 ppm AFFF with Defoamer AF 9020)
Nitrogen, mg/L
60
50
40
30
20
10
0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
STAGE
NO2--N
NO3--N
Org. N
NH3-N

Reactor	AFFF ppm	Defoamer AF 9020	Stage	Time	Nitrogen Concentration, mg/L NH3-N	NO3--N	NO2--N	Δ(NO_3^--N)	Δ(NO_2-N)
A1 (Control)	0	0	End of Feeding	2 hr	24.55	0.8	0.0		
			End of Anaerobic	4 hr	30.02	0.8	0.0		
			End of Aerobic	6 hr	4.67	19.4	2.9		
			End of Settling	8 hr	2.82	19.0	3.1	18.16	3.10
A2 (Control)	0	0	End of Feeding	2 hr	23.97	0.8	0.0		
			End of Anaerobic	4 hr	29.44	0.8	0.0		
			End of Aerobic	6 hr	4.45	18.7	3.2		
			End of Settling	8 hr	3.15	22.1	3.0	21.32	2.97
A3 (Control)	0	0	End of Feeding	2 hr	25.65	0.8	0.0		
			End of Anaerobic	4 hr	30.97	1.0	0.0		
			End of Aerobic	6 hr	3.20	20.0	3.4		
			End of Settling	8 hr	2.78	17.0	3.0	16.19	3.00
B1	60	15	End of Feeding	2 hr	22.31	0.8	0.0		
			End of Anaerobic	4 hr	28.88	0.8	0.0		
			End of Aerobic	6 hr	10.74	11.0	2.9		
			End of Settling	8 hr	11.27	13.5	2.5	12.75	2.49
B2	60	15	End of Feeding	2 hr	23.50	0.8	0.0		
			End of Anaerobic	4 hr	30.26	0.8	0.0		
			End of Aerobic	6 hr	11.85	5.3	2.4		
			End of Settling	8 hr	13.21	9.0	2.7	8.26	2.66
B3	60	15	End of Feeding	2 hr	21.35	0.8	0.0		
			End of Anaerobic	4 hr	30.26	0.8	0.0		
			End of Aerobic	6 hr	12.57	5.5	2.1		
			End of Settling	8 hr	15.37	13.8	2.6	13.01	2.61






25.00
20.00
15.00
10.00
5.00
0.00
Nitrogen, mg/L
A1
A2
A3
B1
B2
B3
NH3–N
Δ(NO2–N)
Δ(NO3—N)

BNR Inhibition Tests - 60 ppm AFFF Pretreated with Defoamer AF9020 (Nov/2/97)

TSS Reactor	Initial wt	Final wt	Volume	MLSS	T @ 550	MLVSS
A1	1.1121	1.157	15	2993	1.117	2667
A2	1.1126	1.1566	15	2933	1.1173	2620
A3	1.1123	1.1545	15	2813	1.1167	2520
B1	1.1207	1.1719	15	3413	1.1264	3033
B2	1.1225	1.1725	15	3333	1.1281	2960
B3	1.1309	1.1852	15	3620	1.137	3213

TDS Reactor	Initial wt	Final wt	Volume	TDS
A1	1.0169	1.0338	15	1127
A2	1.0237	1.0388	15	1007
A3	1.024	1.038	15	933
B1	1.0363	1.0561	15	1320
B2	1.0255	1.0415	15	1067
B3	1.0377	1.0587	15	1400

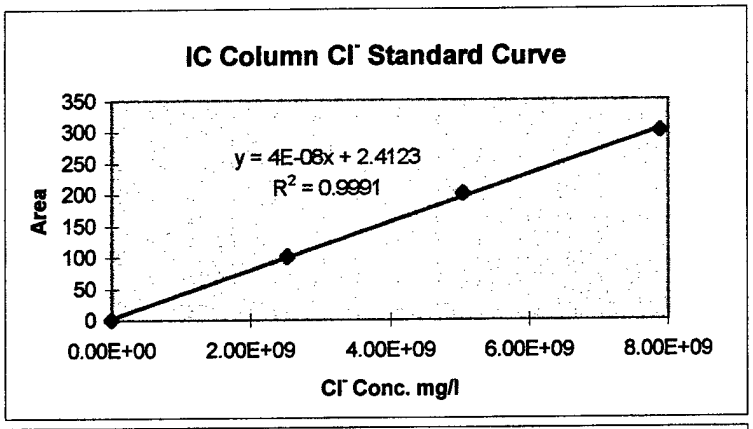
TS Reactor	Initial wt	Final wt	Volume	TS	TSS,TDS
A1	1.0146	1.0759	15	4087	4120
A2	1.0167	1.0775	15	4053	3940
A3	1.0179	1.0799	15	4133	3747
B1	1.0241	1.1017	15	5173	4733
B2	1.0263	1.104	15	5180	4400
B3	1.0280	1.1042	15	5080	5020

BNR Inhibition Batch Assay Pretreated with Best Performing Defoamer

(AFFF 120 ppm)

Reactor	AFFF (ppm)	Defoamer AF9020 ml/liter	Stage	Time	NH3-N (mg/L)	TKN (mg/L)	Alkalinity
			Feedstock		32.2	80.7	493.0
			RR Decant		0.1	11.9	295.0
A1	0	0	End of Feeding	2 hr	26.3	67.9	483.0
			End of Anaerobic	4 hr	31.1	55.1	462.0
			End of Aerobic	6 hr	2.3	15.6	322.0
			Extended Aeration	(4hr)	0.1	7.7	290.0
			End of Settling	8 hr	0.0	5.7	299.0
A2	0	0	End of Feeding	2 hr	23.3	64.1	468.0
			End of Anaerobic	4 hr	28.7	52.1	513.0
			End of Aerobic	6 hr	2.9	13.8	299.0
			End of Settling	8 hr	2.2	17.5	305.0
B1	0	30	End of Feeding	2 hr	20.7	57.1	483.0
			End of Anaerobic	4 hr	28.7	49.3	462.0
			End of Aerobic	6 hr	3.9	19.7	362.0
			End of Settling	8 hr	2.9	14.1	355.0
B2	0	30	End of Feeding	2 hr	19.9	101.8	477.0
			End of Anaerobic	4 hr	28.7	55.1	501.0
			End of Aerobic	6 hr	3.5	18.6	335.0
			Extended Aeration	(4hr)	0.1	8.0	310.0
			End of Settling	8 hr	0.1	6.4	316.0
C1	120	30	End of Feeding	2 hr	20.7	171.3	444.0
			End of Anaerobic	4 hr	31.0	81.4	490.0
			End of Aerobic	6 hr	11.5	29.8	396.0
			End of Settling	8 hr	6.6	16.7	387.0
C2	120	30	End of Feeding	2 hr	19.9	85.5	472.0
			End of Anaerobic	4 hr	29.8	96.2	437.0
			End of Aerobic	6 hr	13.0	15.6	400.0
			Extended Aeration	(4hr)	0.05	13.34	294
			End of Settling	8 hr	0.07	17.7	311.0

Reactor	AFFF (ppm)	Defoamer AF9020 ml/liter	Stage	Time	Cl-		NO_2^--N		NO_3^--N		PO4-P	
					Area	(mg/L)	Area	(mg/L)	Area	(mg/L)	Absorb.	mg/l
			Feedstock		7054379476	271.7	0	0.0	9902431	1.1	0.366	11.71
			RR Decant		5734515761	221.3	16370108	0.4	996533663	17.7	0.052	1.93
A1	0	0	End of Feeding	2 hr	6348421565	244.8	0	0.0	3849770	0.9	1.351	42.40
			End of Anaerobic	4 hr	5994018561	231.3	0	0.0	4797019	1.0	1.313	41.21
			End of Aerobic	6 hr	6169545264	238.0	271036986	6.4	1126185695	19.9	0.529	16.79
			Extended Aeration	(4hr)	6267692633	241.7	0	0.0	1787334663	31.1	0.258	8.35
			End of Settling	8 hr	6311578450	243.4	0	0.0	1785261984	31.1	0.241	7.82
A2	0	0	End of Feeding	2 hr	6202705931	239.2	0	0.0	2350208	0.9	1.418	44.48
			End of Anaerobic	4 hr	6191501229	238.8	0	0.0	184122	0.9	1.513	47.44
			End of Aerobic	6 hr	6255671833	241.2	266251370	6.3	1079785510	19.2	0.368	11.78
			End of Settling	8 hr	6208634134	239.4	241528645	5.7	874891000	15.7	0.446	14.21
B1	0	30	End of Feeding	2 hr	430780220	226.3	0	0.0	1660856	0.9	1.807	56.60
			End of Anaerobic	4 hr	420167237	221.4	0	0.0	2433724	0.9	1.628	51.03
			End of Aerobic	6 hr	424214043	223.3	15462091	4.4	50983819	20.9	0.448	14.27
			End of Settling	8 hr	440646369	230.8	17074983	4.9	52814085	21.3	0.375	12.00
B2	0	30	End of Feeding	2 hr	412011695	217.7	1158193	0.1	4824306	1.0	1.085	34.11
			End of Anaerobic	4 hr	413015053	218.2	2150122	0.1	3879584	0.9	1.708	53.52
			End of Aerobic	6 hr	442187880	231.5	16477617	4.7	56288014	22.0	0.688	21.75
			Extended Aeration	(4hr)	469608591	244.1	2709918	0.8	90396623	29.0	0.588	18.63
			End of Settling	8 hr	446746147	233.6	2538866	0.7	84010344	27.7	0.603	19.10
C1	120	30	End of Feeding	2 hr	429190296	225.6	0	0.0	1619044	0.9	1.595	50.00
			End of Anaerobic	4 hr	423750052	223.1	0	0.0	3811496	0.9	1.642	51.46
			End of Aerobic	6 hr	439228579	230.2	8380591	2.4	40313185	18.8	0.966	30.40
			End of Settling	8 hr	425798596	224.0	9741585	2.8	39107556	18.5	0.934	29.41
C2	120	30	End of Feeding	2 hr	407279466	215.5	729742	0.1	1841106	0.9	1.658	51.96
			End of Anaerobic	4 hr	414717322	218.9	0	0.0	17034729	1.2	1.747	54.73
			End of Aerobic	6 hr	421088553	221.9	8343067	2.4	29085719	16.5	0.881	27.76
			Extended Aeration	(4hr)	429931641	225.9	4392062	1.3	75586351	25.9	0.369	11.8
			End of Settling	8 hr	441428568	231.2	2962652	0.8	86642505	28.2	0.616	19.50
			stand 2		2472225244	96.80	427056958	10.15	498963689	9.33		
			Stand 3		5095839709	197.0	871460063	20.7	1087463930	19.3		
			stand 4		7600127427	292.6	1.644E+09	39.1	2320505088	40.2		
			Standards used									
			STD 1		3257406	0	0	0	1034310	0	0.156	5
			STD 2		2528446248	100	425265034	10	497596898	10	0.624	20
			STD 3		5043256928	200	861191951	20	1090488678	20	1.113	35
			STD 4		7887900239	300	1.672E+09	40	2338151857	40	1.598	50



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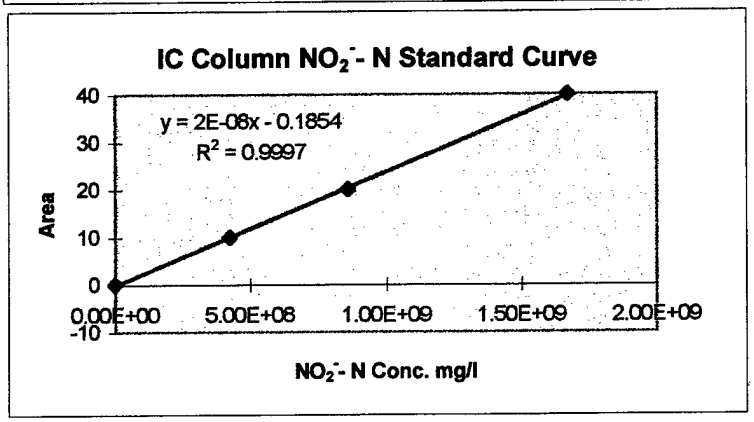

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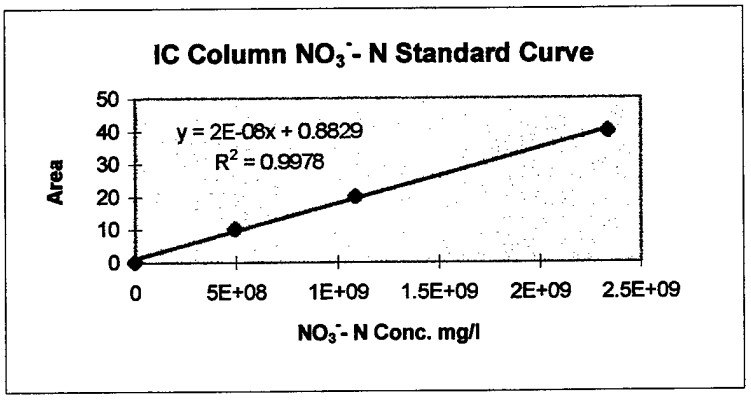

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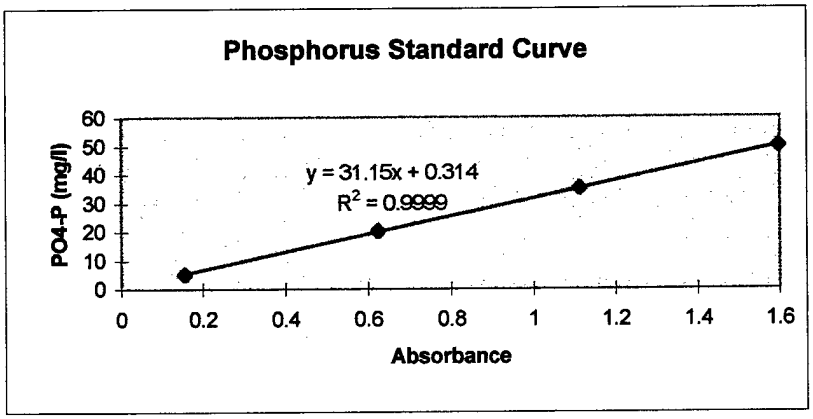


SUMMARY OUTPUT

CL

Regression Statistics	
R Square	0.999086704
Observations	4

	Coefficients	*Standard Error*
Intercept	2.412275642	3.957771334
X Variable 1	3.81786E-08	8.16224E-10

SUMMARY OUTPUT

NO2-N

Regression Statistics	
R Square	0.999722165
Observations	4

	Coefficients	*Standard Error*
Intercept	0	0.271753644
X Variable 1	2.37647E-08	2.81876E-10

SUMMARY OUTPUT

NO3-N

Regression Statistics	
R Square	0.997784521
Observations	4

	Coefficients	*Standard Error*
Intercept	0.882869329	0.740861883
X Variable 1	1.69249E-08	5.6393E-10

SUMMARY OUTPUT

PO4-P

Regression Statistics	
R Square	0.999910723
Observations	4

	Coefficients	*Standard Error*
Intercept	0.313953782	0.21342196
X Variable 1	31.14986676	0.208127792

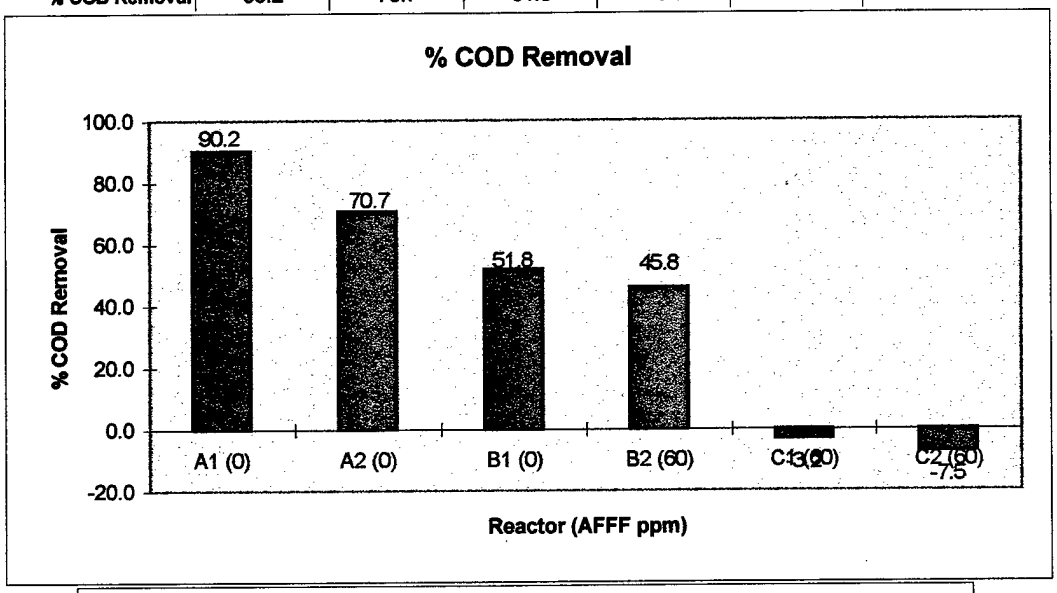
Reactor	AFFF (ppm)	Defoamer AF9020	Stage	Time	COD		
					ABS	(mg/L)	% COD Removal*
			Feedstock		0.086	**1102.0**	
			RR Decant		0.003	**38.4**	
A1	0	0	End of Feeding	2 hr	0.007	**89.7**	77.2
			End of Anaerobic	4 hr	0.012	**153.8**	60.9
			End of Aerobic	6 hr	0.003	**38.4**	90.2
			Extended Aeration	(4hr)	0.005	**64.1**	83.7
			End of Settling	8 hr	0.003	**38.4**	**90.2**
A2	0	0	End of Feeding	2 hr	0.005	**64.1**	83.7
			End of Anaerobic	4 hr	0.007	**89.7**	77.2
			End of Aerobic	6 hr	0.012	**153.8**	60.9
			End of Settling	8 hr	0.009	**115.3**	**70.7**
B1	0	30	End of Feeding	2 hr	0.067	**858.5**	**32.7**
			End of AnaerobiC	4 hr	0.060	**768.8**	39.8
			End of Aerobic	6 hr	0.052	**666.3**	47.8
			End of Settling	8 hr	0.048	**615.1**	**51.8**
B2	0	30	End of Feeding	2 hr	0.073	**935.4**	26.7
			End of Anaerobic	4 hr	0.083	**1063.6**	16.7
			End of Aerobic	6 hr	0.056	**717.6**	43.8
			Extended Aeration	(4hr)	0.06	**768.8**	39.8
			End of Settling	8 hr	0.054	**692.0**	**45.8**
C1	120	30	End of Feeding	2 hr	0.171	**2191.2**	9.0
			End of Anaerobic	4 hr	0.160	**2050.2**	14.9
			End of Aerobic	6 hr	0.157	**2011.8**	16.5
			End of Settling	8 hr	0.194	**2485.9**	**-3.2**
C2	120	30	End of Feeding	2 hr	0.186	**2383.4**	1.0
			End of Anaerobic	4 hr	0.154	**1973.4**	18.1
			End of Aerobic	6 hr	0.161	**2063.1**	14.3
			End of Anaerobic	4 hr	0.191	**2447.5**	-1.6
			End of Settling	8 hr	0.202	**2588.4**	**-7.5**
			STD 1		0.000	0	
			STD 2		0.079	1000	
			STD 3		0.167	2000	
			STD 4		0.242	3000	
			STD 5		0.340	4500	
			FS (Filtered)		0.095	1217.3	
			FS (Filtered)		0.076	973.9	
			FS Average		**0.086**	**1095.6**	
			RRSU(Filtered)		0.001	12.8	
			RRSU(Filtered)		0.005	**64.1**	
			RRSU Average		**0.003**	**38.4**	

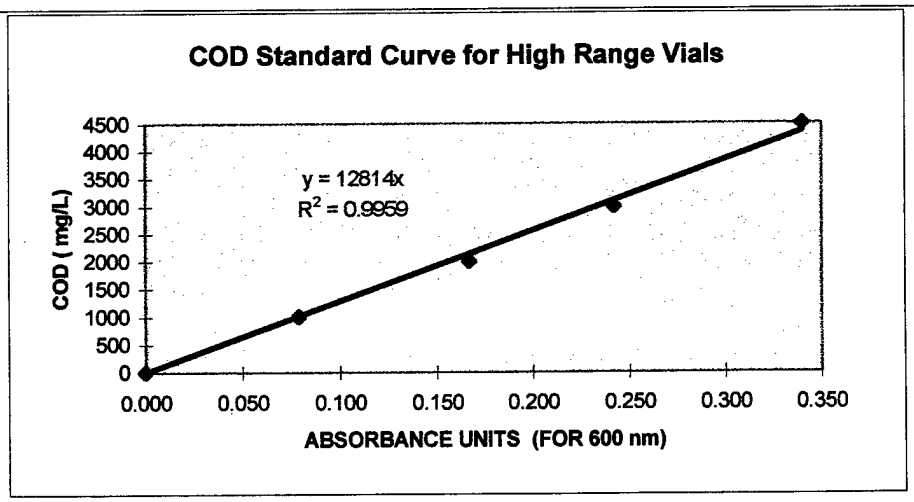
* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.

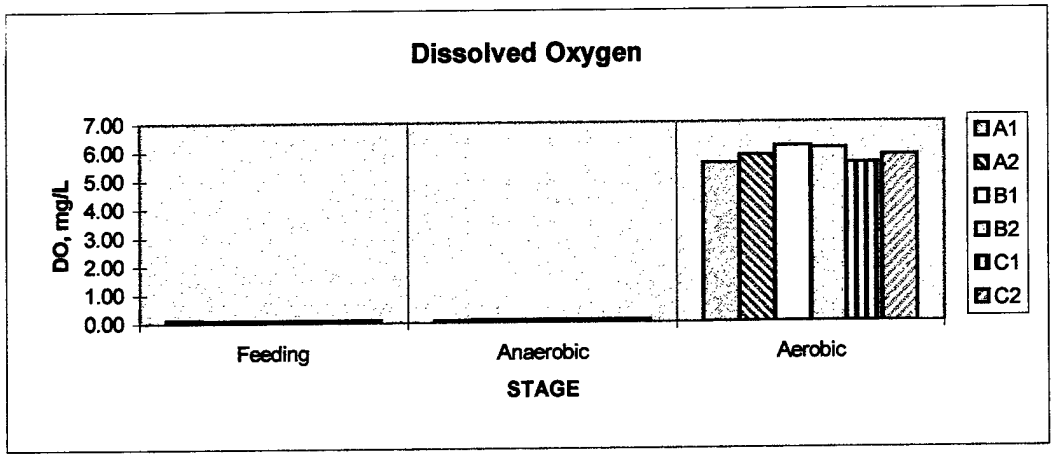
Initial COD at Time 0 hr.

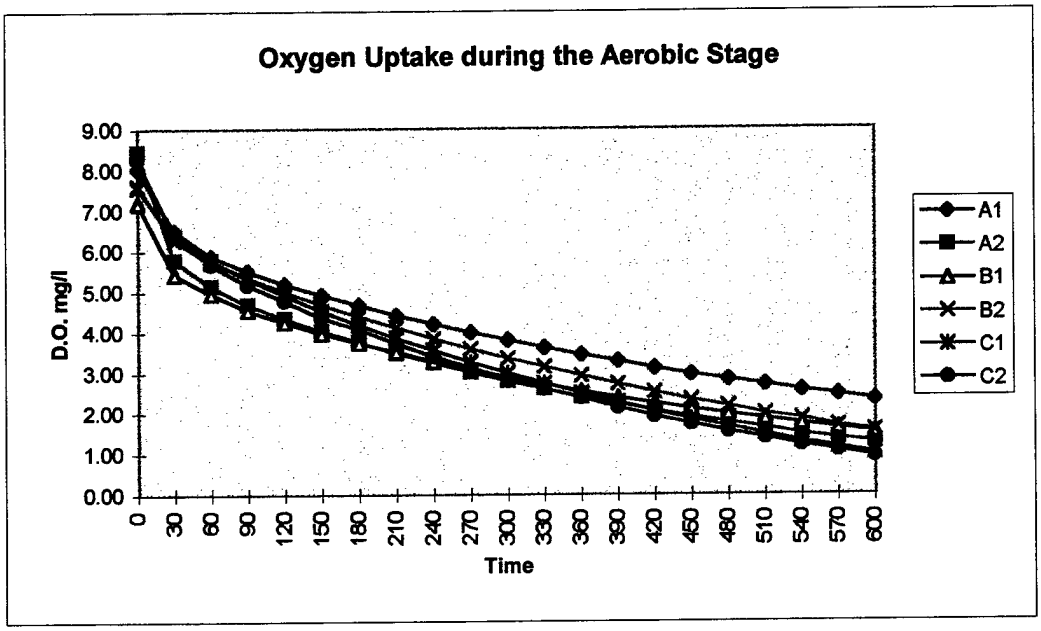
Sample	Constituent	Vol (L)	COD mg/L	
Controls	RR Decant	4	38.4	153.768
(A1,A2)	Feedstock	2	1102.0	2204.008
	AFFF	0	0	0
	Total	6		**393.0**
Inhibition	RR Decant	4	38.4	153.768
(B1,B2)	Feedstock	2	1102.0	2204.008
	Defoamer		5300	5300
	Total	6		**1276.3**
	RR Decant	4	38.4	153.768
(C1,C2)	Feedstock	2	1102.0	2204.008
	AFFF	2	3396	6792
	Defoamer	1	5300	5300
	Total	6		**2408.3**

Reactor (AFFF ppm)	A1 (0)	A2 (0)	B1 (0)	B2 (60)	C1 (60)	C2 (60)
% COD Removal	90.2	70.7	51.8	45.8	-3.2	-7.5






Dissolved Oxygen
DO, mg/L
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
B1
B2
C1
C2

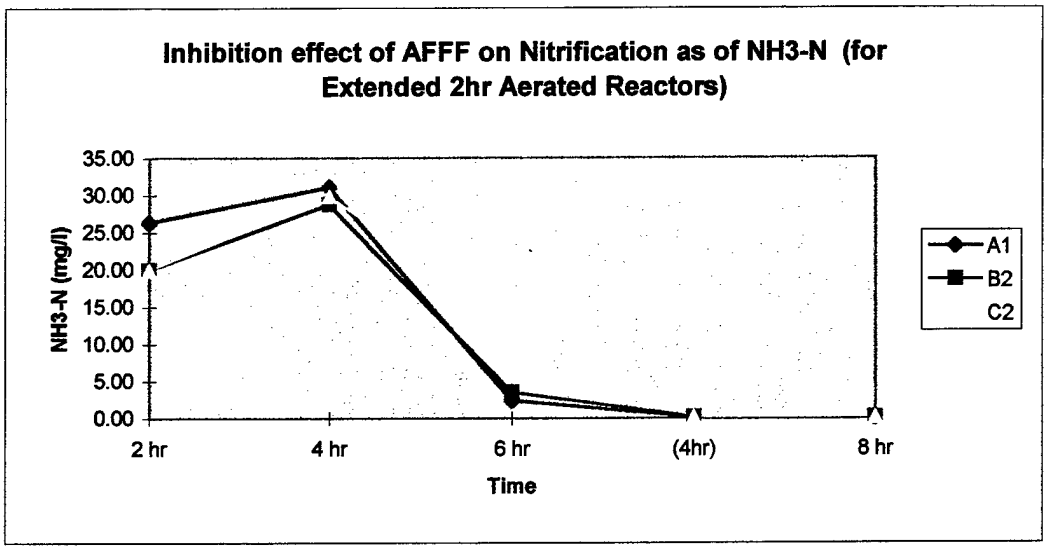

Oxygen Uptake during the Aerobic Stage
D.O. mg/l
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
Time
A1
A2
B1
B2
C1
C2

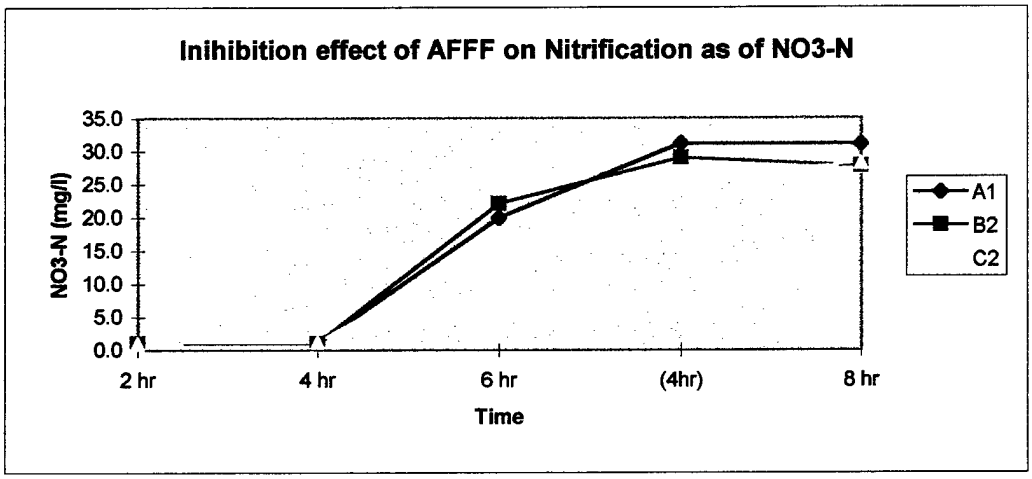
Stage	Dissolved Oxygen (mg/L) at various stages					
	A1	A2	B1	B2	C1	C2
Feeding	0.11	0.09	0.09	0.09	0.08	0.10
Anaerobic	0.07	0.08	0.09	0.09	0.10	0.09
Aerobic	5.58	5.84	6.17	6.10	5.57	5.85

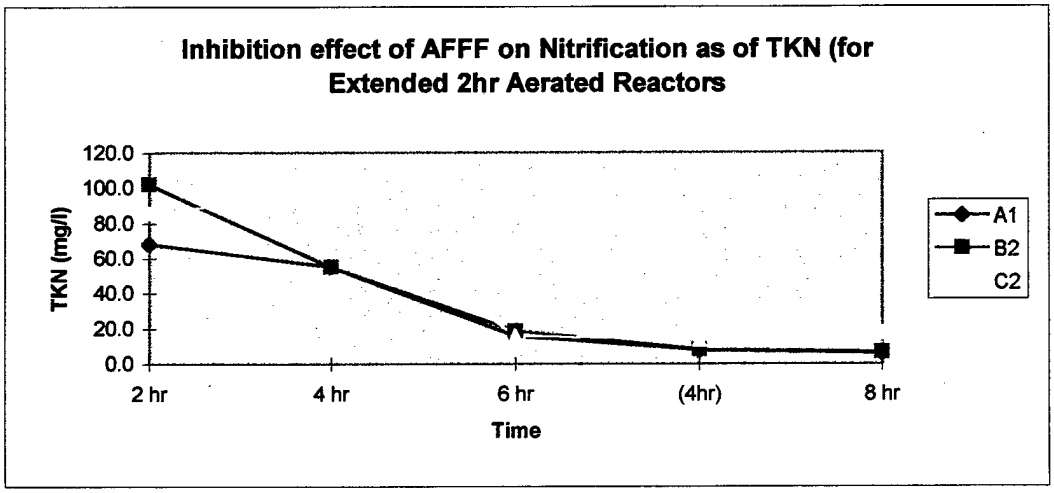
Stage	Time (sec)	Dissolved Oxygen in mg/L					
		A1	A2	B1	B2	C1	C2
Aerobic	0	8.02	8.43	7.20	7.61	7.56	8.25
	30	6.49	5.77	5.42	6.26	6.37	6.38
	60	5.86	5.12	4.96	5.72	5.77	5.66
	90	5.50	4.68	4.54	5.35	5.31	5.16
	120	5.18	4.32	4.25	4.98	4.90	4.76
	150	4.90	4.02	3.97	4.67	4.52	4.35
	180	4.66	3.74	3.73	4.37	4.17	4.06
	210	4.40	3.47	3.51	4.11	3.84	3.71
	240	4.18	3.23	3.27	3.83	3.54	3.39
	270	3.98	2.99	3.07	3.58	3.25	3.11
	300	3.79	2.77	2.88	3.34	2.98	2.83
	330	3.60	2.58	2.71	3.13	2.73	2.59
	360	3.43	2.38	2.54	2.91	2.48	2.36
	390	3.27	2.22	2.39	2.72	2.26	2.13
	420	3.10	2.05	2.24	2.51	2.04	1.92
	450	2.95	1.89	2.10	2.32	1.84	1.72
	480	2.83	1.75	1.97	2.16	1.66	1.54
	510	2.69	1.63	1.86	1.98	1.48	1.38
	540	2.56	1.48	1.74	1.85	1.29	1.21
	570	2.44	1.37	1.63	1.68	1.15	1.06
	600	2.32	1.27	1.54	1.55	1.01	0.92

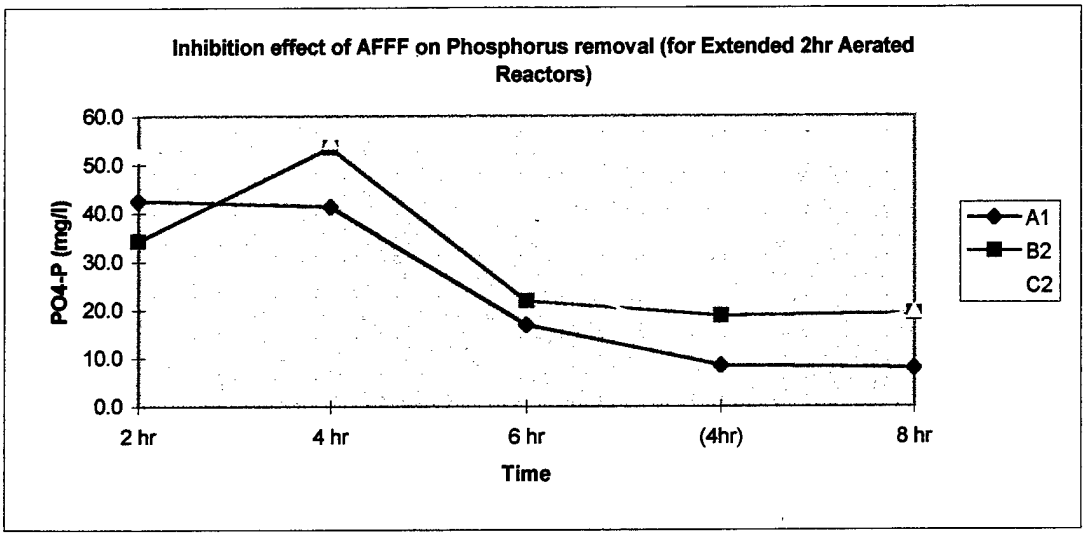
Reactor	AFFF (ppm)	Defoamer AF9020	Stage	Time	Concentration, mg/L							
					TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
			Feedstock		80.7	32.19	48.5	0.0	1.1	81.8	271.7	11.7
			RR Decant		11.9	0.11	11.8	0.4	17.7	30.0	221.3	1.9
A1	0	0	End of Feeding	2 hr	67.9	26.33	41.5	0.0	0.9	68.8	244.8	42.4
			End of Anaerobic	4 hr	55.1	31.05	24.0	0.0	1.0	56.0	231.3	41.2
			End of Aerobic	6 hr	15.6	2.34	13.2	6.4	19.9	42.0	238.0	16.8
			Extended Aeration	(4hr)	7.7	0.05	7.6	0.0	31.1	38.8	241.7	8.4
			End of Settling	8 hr	5.7	0.01	5.7	0.0	31.1	36.8	243.4	7.8
A2	0	0	End of Feeding	2 hr	64.1	23.34	40.7	0.0	0.9	65.0	239.2	44.5
			End of Anaerobic	4 hr	52.1	28.67	23.4	0.0	0.9	53.0	238.8	47.4
			End of Aerobic	6 hr	13.8	2.86	11.0	6.3	19.2	39.3	241.2	11.8
			End of Settling	8 hr	17.5	2.19	15.3	5.7	15.7	39.0	239.4	14.2
B1	0	30	End of Feeding	2 hr	57.1	20.69	36.4	0.0	0.9	58.0	226.3	56.6
			End of Anaerobic	4 hr	49.3	28.67	20.6	0.0	0.9	50.2	221.4	51.0
			End of Aerobic	6 hr	19.7	3.93	15.8	4.4	20.9	45.1	223.3	14.3
			End of Settling	8 hr	14.1	2.89	11.2	4.9	21.3	40.3	230.8	12.0
B2	0	30	End of Feeding	2 hr	101.8	19.88	81.9	0.1	1.0	102.8	217.7	34.1
			End of Anaerobic	4 hr	55.1	28.67	26.4	0.1	0.9	56.1	218.2	53.5
			End of Aerobic	6 hr	18.6	3.49	15.1	4.7	22.0	45.3	231.5	21.7
			Extended Aeration	(4hr)	8.0	0.05	8.0	0.8	29.0	37.7	244.1	18.6
			End of Settling	8 hr	6.4	0.09	6.3	0.7	27.7	34.8	233.6	19.1
C1	120	30	End of Feeding	2 hr	171.3	20.69	150.6	0.0	0.9	172.2	225.6	50.0
			End of Anaerobic	4 hr	81.4	31.00	50.4	0.0	0.9	82.3	223.1	51.5
			End of Aerobic	6 hr	29.8	11.54	18.3	2.4	18.8	51.0	230.2	30.4
			End of Settling	8 hr	16.7	6.64	10.1	2.8	18.5	38.0	224.0	29.4
C2	120	30	End of Feeding	2 hr	85.5	19.88	65.7	0.1	0.9	86.5	215.5	52.0
			End of Anaerobic	4 hr	96.2	29.84	66.3	0.0	1.2	97.3	218.9	54.7
			End of Aerobic	6 hr	15.6	13.00	15.6	2.4	16.5	47.4	221.9	27.757
			Extended Aeration	(4hr)	13.3	0.05	13.3	1.3	25.9	40.5	225.9	11.808
			End of Settling	8 hr	17.7	0.07	17.6	0.8	28.2	46.7	231.2	19.502

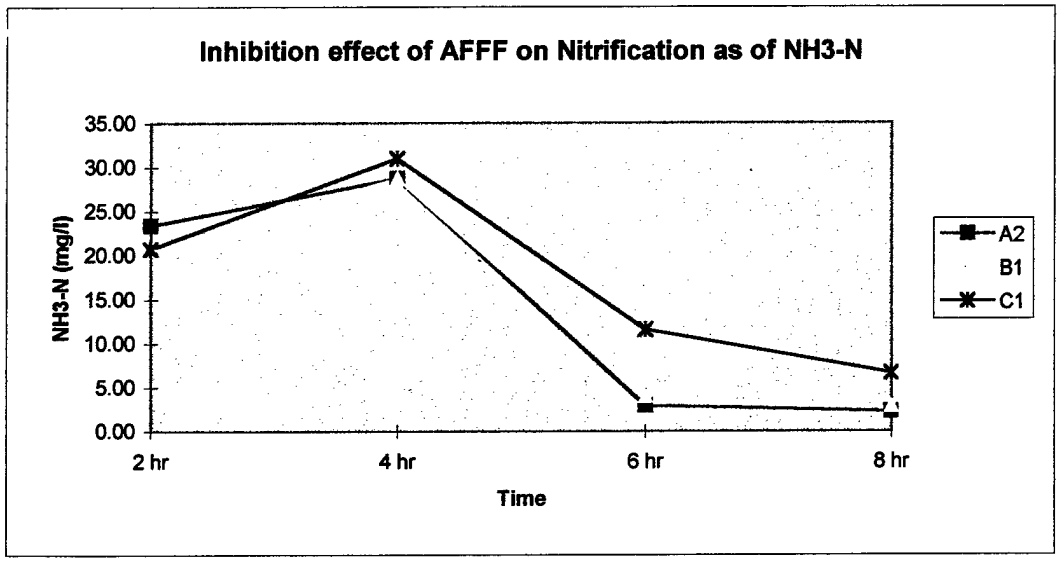
Reactor	AFFF (ppm)	Defoamer AF9020	Stage	Time	Concentration, mg/L BOD	COD	TOC	Alkalinity HCO3 (mg/l)
			Feedstock			1102.0	381.7	430.0
			RR Decant			38.4	12.8	319.0
A1	0	0	End of Feeding	2 hr		89.7	**25.4**	501.0
			End of Anaerobic	4 hr		153.8	18.04	473.0
			End of Aerobic	6 hr		38.4	13.4	287.0
			Extended Aeration	(4hr)		64.1	14.42	297.0
			End of Settling	8 hr		38.4	**13.9**	271.0
A2	0	0	End of Feeding	2 hr		64.1	**24.8**	506.0
			End of Anaerobic	4 hr		89.7	17.57	484.0
			End of Aerobic	6 hr		153.8	**13.3**	273.0
			End of Settling	8 hr		115.3	**11.5**	291.0
B1	0	30	End of Feeding	2 hr		858.5	**241.3**	473.0
			End of Anaerobic	4 hr		768.8	**208.2**	487.0
			End of Aerobic	6 hr		666.3	**118.8**	294.0
			End of Settling	8 hr		615.1	**197.8**	300.0
B2	0	30	End of Feeding	2 hr		935.4	**271.3**	592.0
			End of Anaerobic	4 hr		1063.6	**233.4**	554.0
			End of Aerobic	6 hr		717.6	**139.9**	475.0
			Extended Aeration	(4hr)		768.8	**131.9**	457.0
			End of Settling	8 hr		692.0	**202.0**	433.0
C1	120	30	End of Feeding	2 hr		2191.2	**568.1**	584.0
			End of Anaerobic	4 hr		2050.2	**525.2**	560.0
			End of Aerobic	6 hr		2011.8	**534.4**	487.0
			End of Settling	8 hr		2485.9	**634.3**	503.0
C2	120	30	End of Feeding	2 hr		2383.4	**635.8**	578.0
			End of Anaerobic	4 hr		1973.4	**514.4**	564.0
			End of Aerobic	6 hr		2063.1	548.0	485
			Extended Aeration	(4hr)		2447.5	651.4	
			End of Settling	8 hr		2588.4	655.1	477
			FS1				380.7	
			FS2				384.0	
			FS3				380.4	
			FS Avarage				381.7	
			RRSU1				13.8	
			RRSU2				12.2	
			RRSU3				12.3	
			RRSU Avarage				12.80	

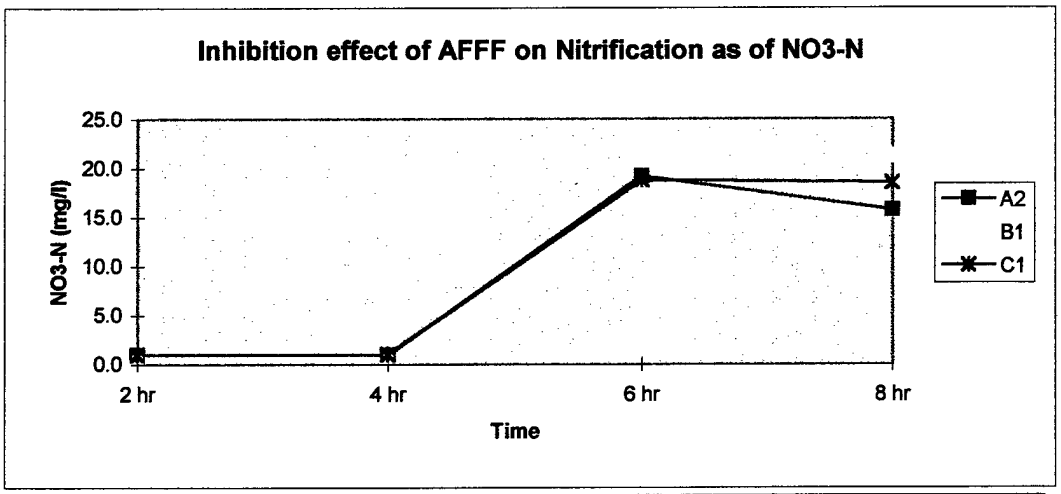

Inhibition effect of AFFF on Nitrification as of NH3-N (for Extended 2hr Aerated Reactors)
NH3-N (mg/l)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2 hr
4 hr
6 hr
(4hr)
8 hr
Time
A1
B2
C2

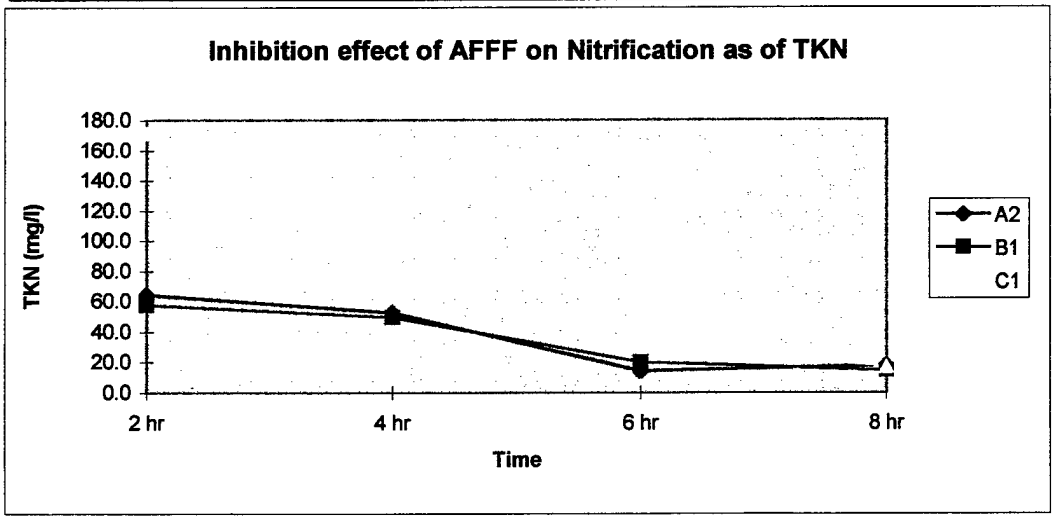

Inihibition effect of AFFF on Nitrification as of NO3-N
NO3-N (mg/l)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
(4hr)
8 hr
Time
A1
B2
C2

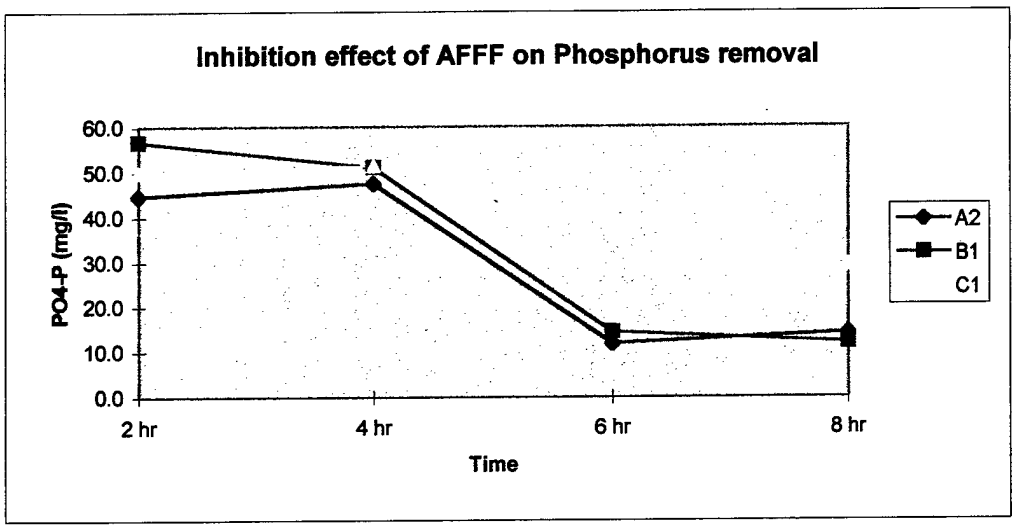

Inhibition effect of AFFF on Nitrification as of TKN (for Extended 2hr Aerated Reactors
TKN (mg/l)
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2 hr
4 hr
6 hr
(4hr)
8 hr
Time
A1
B2
C2

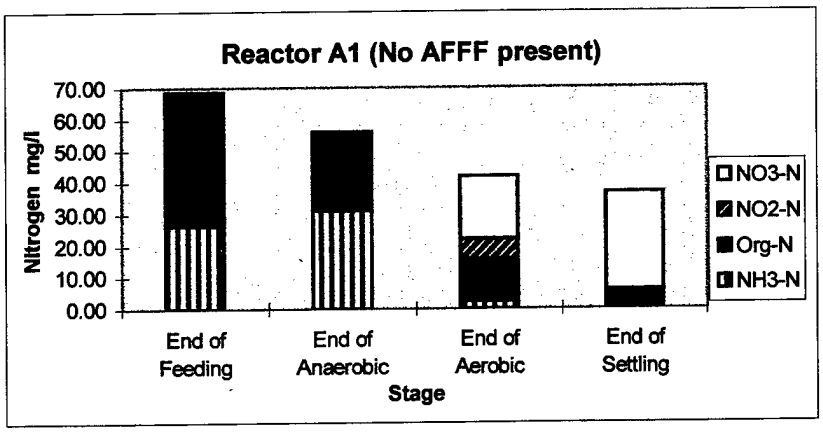

Inhibition effect of AFFF on Phosphorus removal (for Extended 2hr Aerated Reactors)
PO4-P (mg/l)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2 hr
4 hr
6 hr
(4hr)
8 hr
Time
A1
B2
C2

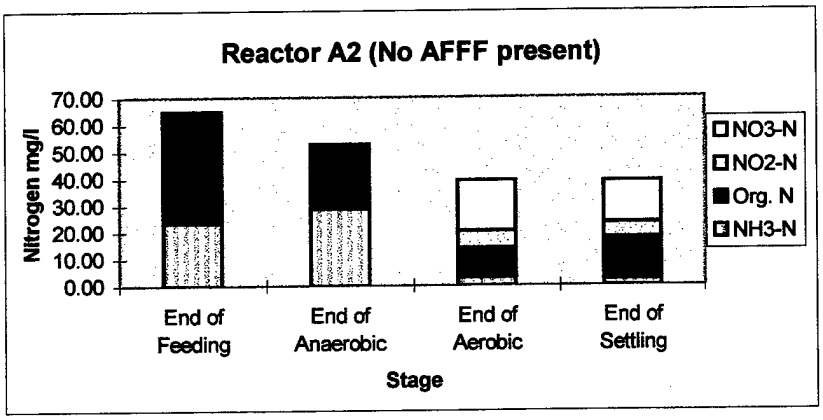

Inhibition effect of AFFF on Nitrification as of NH3-N
NH3-N (mg/l)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2 hr
4 hr
6 hr
8 hr
Time
A2
B1
C1

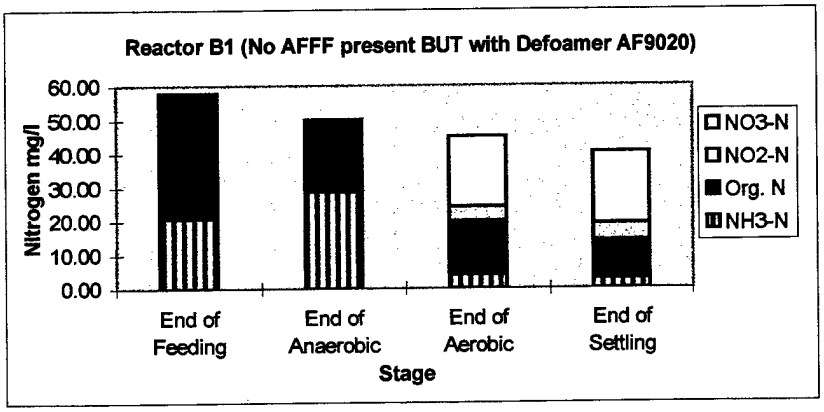

Inhibition effect of AFFF on Nitrification as of NO3-N
NO3-N (mg/l)
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A2
B1
C1

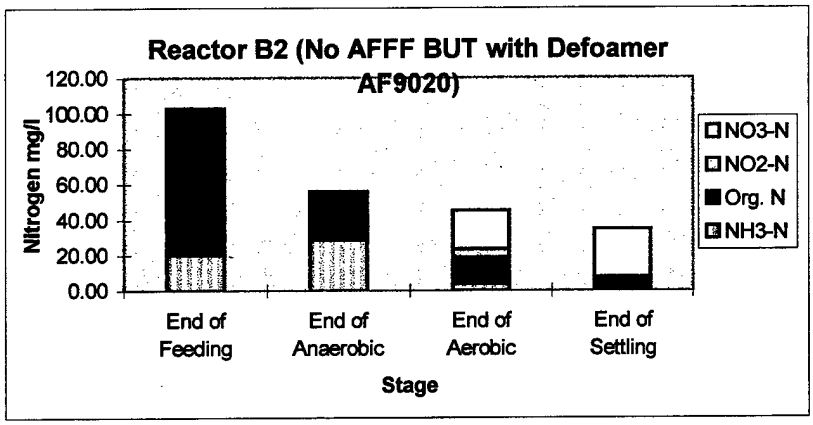

Inhibition effect of AFFF on Nitrification as of TKN
TKN (mg/l)
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A2
B1
C1

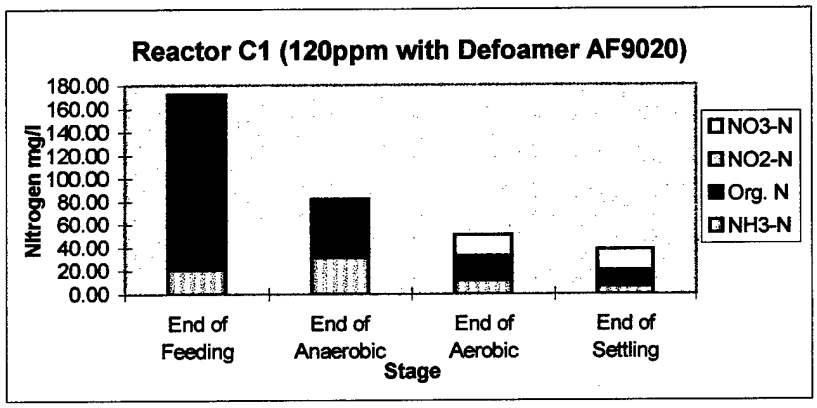

Inhibition effect of AFFF on Phosphorus removal
60.0
50.0
40.0
30.0
20.0
10.0
0.0
PO4-P (mg/l)
2 hr
4 hr
6 hr
8 hr
Time
A2
B1
C1

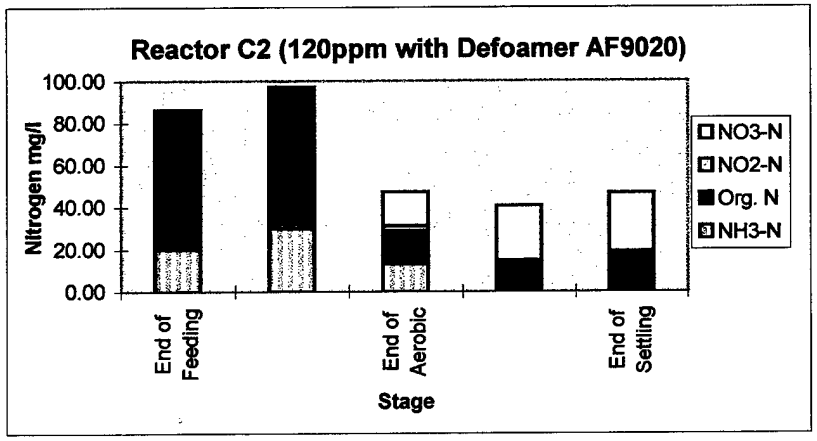

Reactor A1 (No AFFF present)
Nitrogen mg/l
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org-N
NH3-N


Reactor A2 (No AFFF present)
Nitrogen mg/l
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

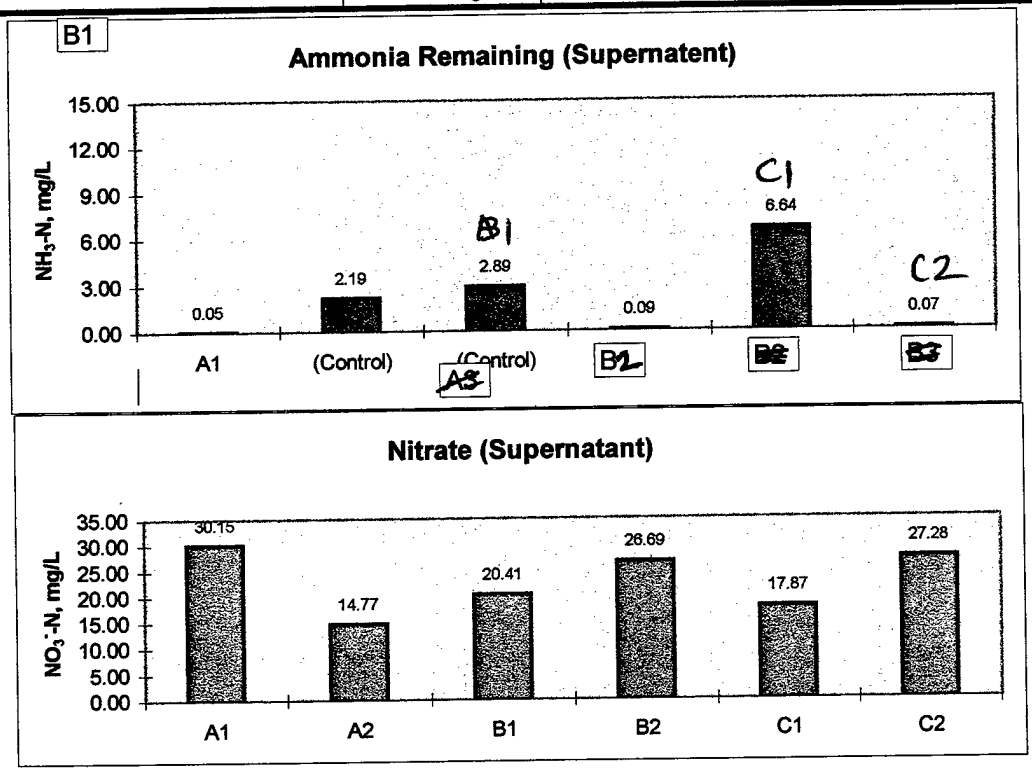

Reactor B1 (No AFFF present BUT with Defoamer AF9020)
Nitrogen mg/l
60.00
50.00
40.00
30.00
20.00
10.00
0.00
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

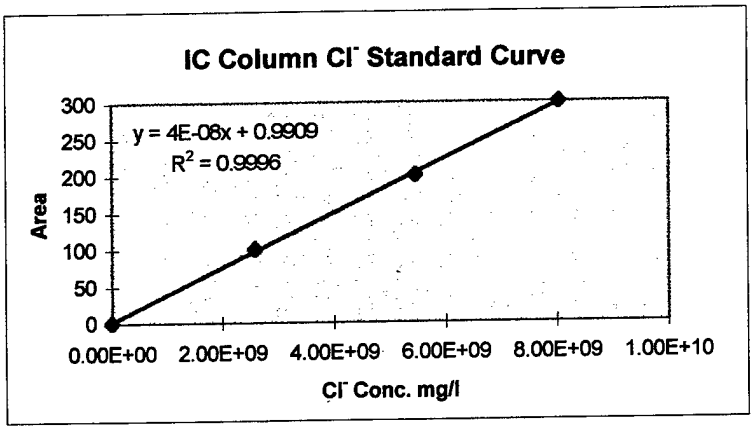

Reactor B2 (No AFFF BUT with Defoamer AF9020)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Nitrogen mg/l
NO3-N
NO2-N
Org. N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage


Reactor C1 (120ppm with Defoamer AF9020)
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Nitrogen mg/l
NO3-N
NO2-N
Org. N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage


Reactor C2 (120ppm with Defoamer AF9020)
100.00
80.00
60.00
40.00
20.00
0.00
Nitrogen mg/l
NO3-N
NO2-N
Org. N
NH3-N
End of Feeding
End of Aerobic
End of Settling
Stage

Reactor	AFFF ppm	Defoamer AF 9020 ml/liter	Stage	Time	Nitrogen Concentration, mg/L NH3-N	NO3--N	NO2--N	Δ(NO_3^--N)
A1	0	0	End of Feeding	2 hr	26.33	0.9	0.0	
(Control)			End of Anaerobic	4 hr	31.05	1.0	0.0	
			End of Aerobic	6 hr	2.34	19.9	6.4	
			Extended Aeration	(4hr)	0.05	31.1	0.0	
			End of Settling	8 hr	0.01	31.1	0.0	30.15
A2	0	0	End of Feeding	2 hr	23.34	0.9	0.0	
(Control)			End of Anaerobic	4 hr	28.67	0.9	0.0	
			End of Aerobic	6 hr	2.86	19.2	6.3	
			End of Settling	8 hr	2.19	15.7	5.7	14.77
B1	0	30	End of Feeding	2 hr	20.69	0.9	0.0	
~~(Control)~~			End of Anaerobic	4 hr	28.67	0.9	0.0	
			End of Aerobic	6 hr	3.93	20.9	4.4	
			End of Settling	8 hr	2.89	21.3	4.9	20.41
B2	0	30	End of Feeding	2 hr	19.88	1.0	0.1	
			End of Anaerobic	4 hr	28.67	0.9	0.1	
			End of Aerobic	6 hr	3.49	22.0	4.7	
			Extended Aeration	(4hr)	0.05	29.0	0.8	
			End of Settling	8 hr	0.09	27.7	0.7	26.69
C1	120	30	End of Feeding	2 hr	20.69	0.9	0.0	
			End of Anaerobic	4 hr	31.00	0.9	0.0	
			End of Aerobic	6 hr	11.54	18.8	2.4	
			End of Settling	8 hr	6.64	18.5	2.8	17.87
C2	120	30	End of Feeding	2 hr	19.88	0.9	0.1	
			End of Anaerobic	4 hr	29.84	1.2	0.0	
			End of Aerobic	6 hr	13	16.5	2.4	
			Extended Aeration	(4hr)	0.05	25.9	1.3	
			End of Settling	8 hr	0.07	28.2	0.8	27.28





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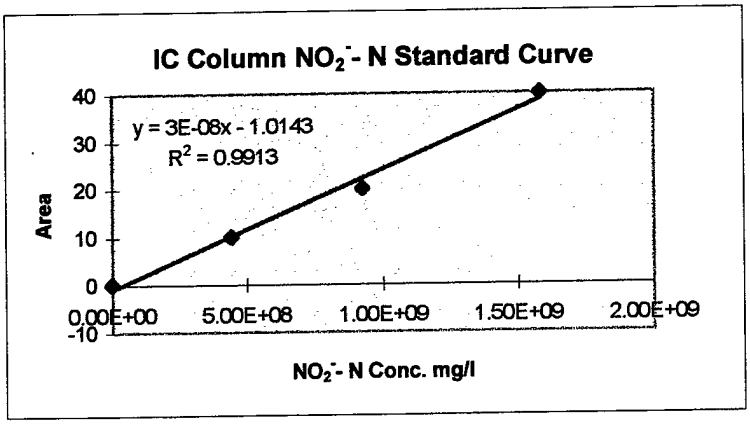
i = *9.91E-01*



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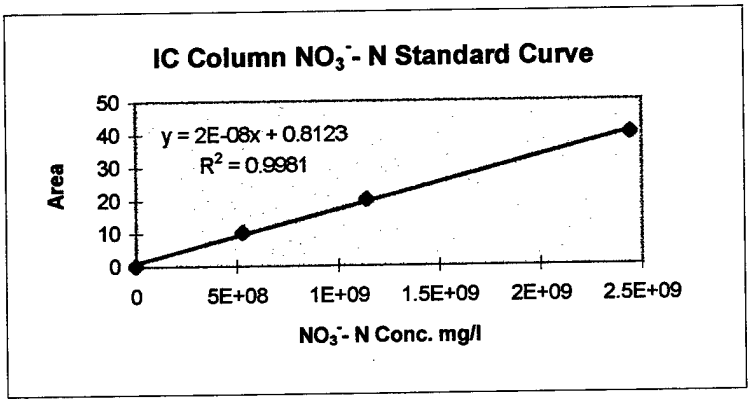
i = *-1.01E+00*



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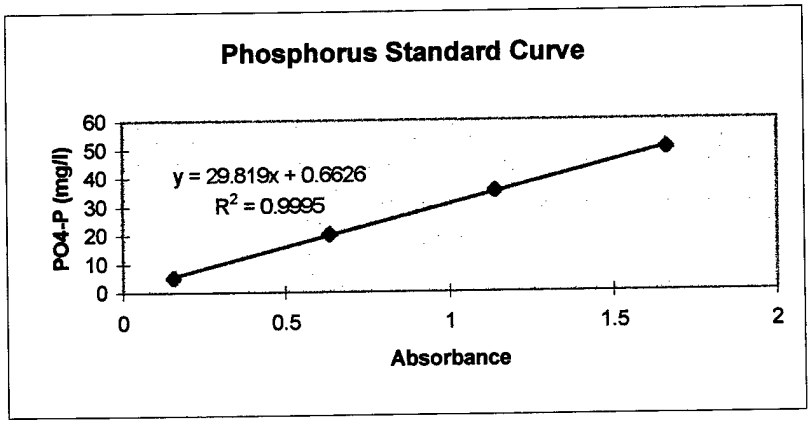


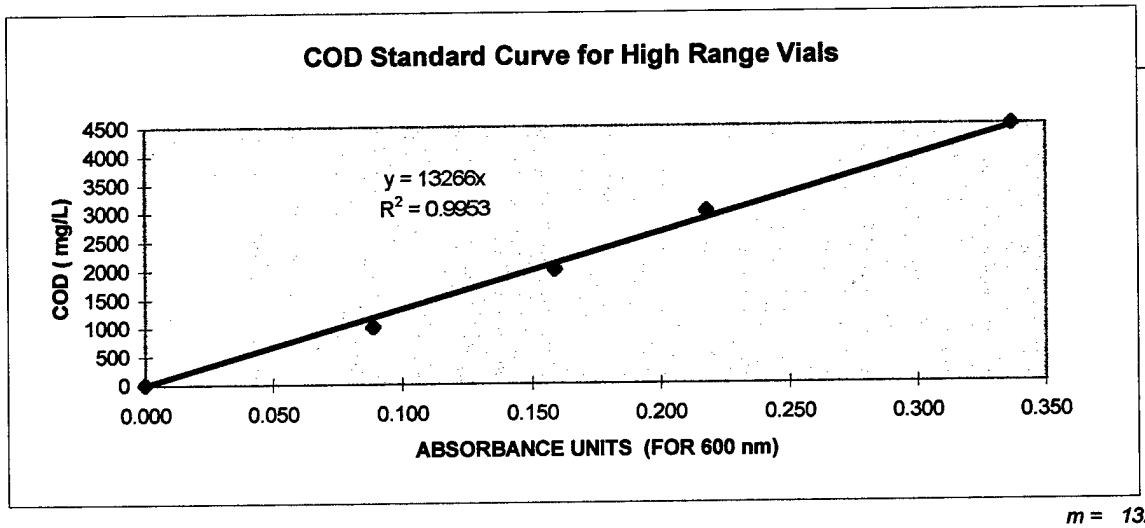
Reactor	AFFF (ppm)	H2O2 mg/l	Fe3+ mg/l	Stage	Time	COD ABS	COD (mg/L)	COD % COD Removal*
				Feedstock		0.380	**973.5**	
				RR Decant		0.021	**53.0**	
A1	0	0	0	End of Feeding **	2 hr	0.030	**76.1**	78.9
				End of Anaerobic**	4 hr	0.018	**45.3**	87.4
				End of Aerobic	6 hr	0.001	**13.3**	96.3
				Extended Aeration	(4hr)	0.001	13.3	96.3
				End of Settling	8 hr	0.002	26.5	**92.6**
A2	0	0	0	End of Feeding**	2 hr	0.029	**73.5**	79.6
				End of Anaerobic **	4 hr	0.021	**53.0**	85.3
				End of Aerobic	6 hr	0.003	39.8	88.9
				End of Settling	8 hr	0.002	26.5	**92.6**
A3	0	0	0	End of Feeding**	2 hr	0.026	**65.8**	81.7
				End of Anaerobic**	4 hr	0.023	**58.1**	83.8
				End of Aerobic	6 hr	0.002	26.5	92.6
				End of Settling	8 hr	0.001	13.3	**96.3**
B1	60	3000	300	End of Feeding**	2 hr	0.107	**273.5**	**67.7**
				End of Anaerobic**	4 hr	0.095	**242.7**	71.3
				End of Aerobic	6 hr	0.010	132.7	84.3
				Extended Aeration	(4hr)	0.008	106.1	87.5
				End of Settling	8 hr	0.007	92.9	**89.0**
B2	60	3000	300	End of Feeding**	2 hr	0.113	**288.9**	65.9
				End of Anaerobic**	4 hr	0.106	**270.9**	68.0
				End of Aerobic	6 hr	0.010	132.7	84.3
				End of Settling	8 hr	0.006	79.6	**90.6**
B3	60	3000	300	End of Feeding**	2 hr	0.123	**314.5**	62.8
				End of Anaerobic	4 hr	0.016	**212.3**	74.9
				End of Aerobic	6 hr	0.012	159.2	81.2
				End of Settling	8 hr	0.006	79.6	**90.6**
				STD 1		0.000	0	} Vials used range
				STD 2		0.089	1000	}from 100mg/l COD
				STD 3		0.159	2000	} TO 4500 mg/l COD
				STD 4		0.218	3000	}
				STD 5		0.337	4500	}
				STD 1**		0.000	0	} Vials used range
				STD 6 **		0.196	500	}from 20mg/l COD
				STD 7 **		0.390	1000	} TO 900 mg/l COD
				FS (Filtered)**		0.380	973.5	
				FS Average**		**0.380**	**973.5**	
				RRSU(Filtered)**		0.021	53.0	
				RRSU Average**		**0.021**	**53.0**	

* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.

** COD measured with standard range vials (Range 20-900 mg/l)

Initial COD at Time 0 hr.

Sample	Constituent	Vol (L)	COD mg/L	
Controls	RR Decant	4	53.0	211.9832
(A1,A2&A3)	Feedstock	2	973.5	1947.0154
	AFFF	0	0	0
	Total	6		**359.8**
Inhibition	RR Decant	4	53.0	211.9832
(B1,B2&B3)	Feedstock	2	973.5	1947.0154
	Fentons Treated AFFF	2	1459	2918
	Total	6		**846.2**



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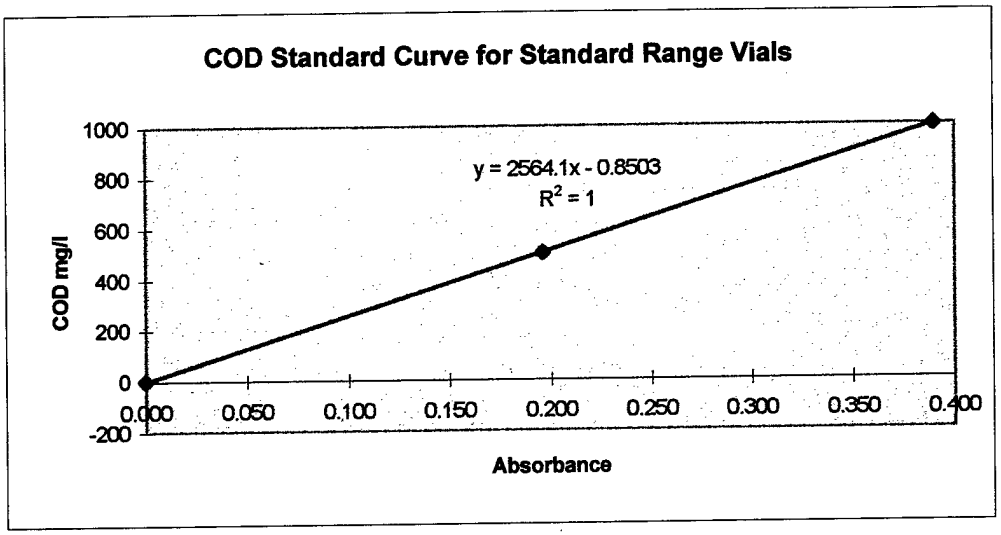
i = 0



Fentons Pretreatment

For AFFF ppm	60 Reactor 1	60 Reactor 2	60 Reactor 3
Tap water	1250 ml	1250 ml	1250 ml
Actual AFFF ppm	150	150	150
	5 ml	5 ml	5 ml
H202, 3000*2.5 mg/l	7500 mg/l	7500 mg/l	7500mg/l
Fe3+ 300*2.5	750 mg/l	750 mg/l	750 mg/l
FeSO4 (3times)	3723.28 mg/l	3723.28 mg/l	3723.28 mg/l

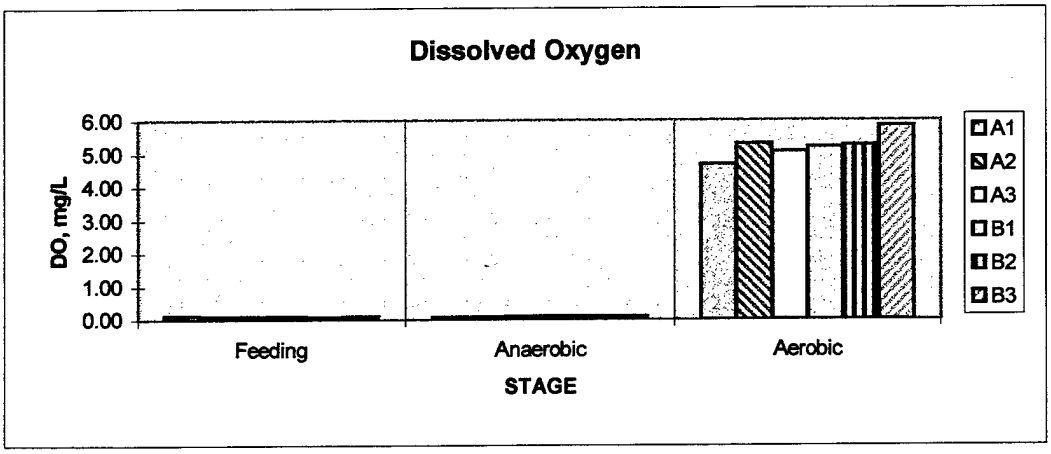
Initial COD

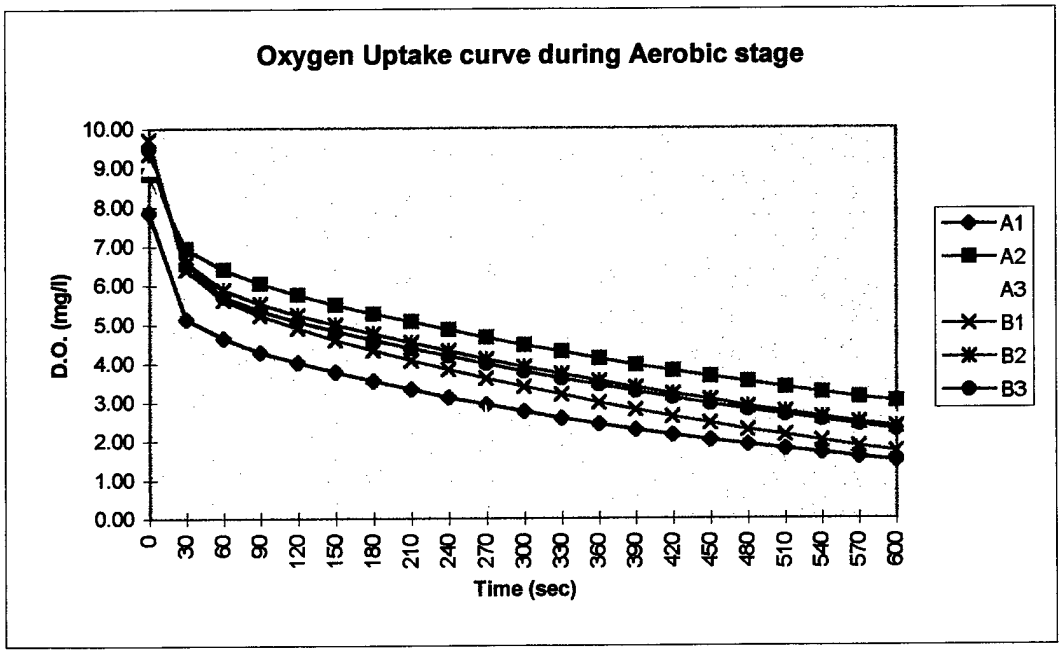
	Absorbance	COD mg/l	Actual COD
AFFF - 60 ppm	0.131	**1737.8**	1737.8

COD after 24 hr reaction period between fentons reagent and AFFF

	Absorbance	COD mg/l	Actual COD
	0.11	**1459.3**	1459.3

% COD Removal 16.03


Dissolved Oxygen
DO, mg/L
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3


Oxygen Uptake curve during Aerobic stage
D.O. (mg/l)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
Time (sec)
A1
A2
A3
B1
B2
B3

Stage	Dissolved Oxygen (mg/L) at various stages					
	A1	A2	A3	B1	B2	B3
Feeding	0.11	0.09	0.09	0.09	0.08	0.10
Anaerobic	0.07	0.08	0.09	0.09	0.10	0.09
Aerobic	4.68	5.30	5.07	5.21	5.27	5.85

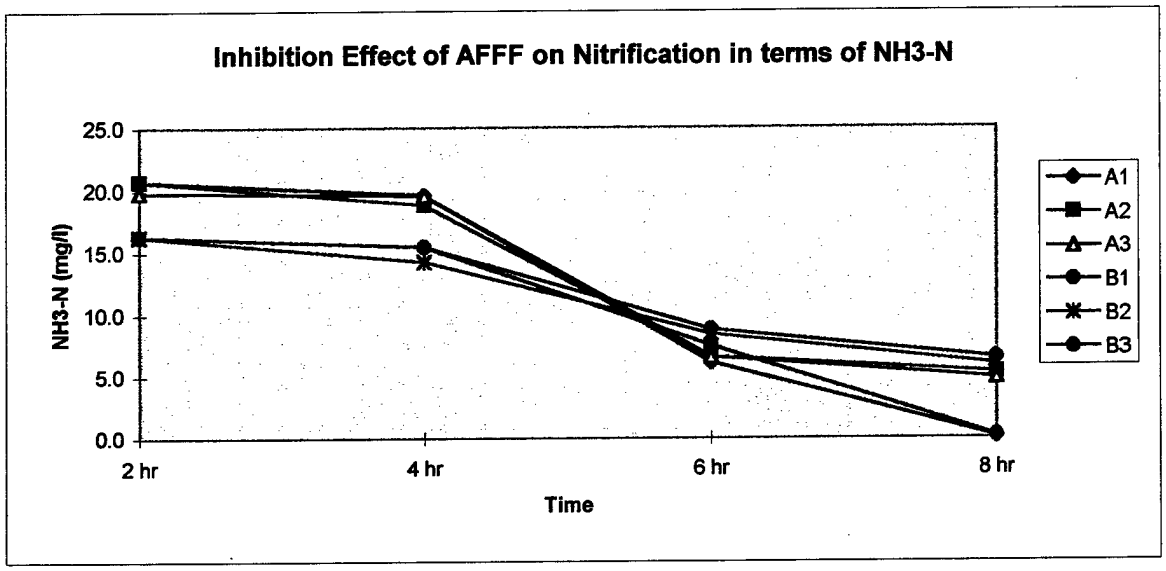
Stage	Time (sec)	Dissolved Oxygen in mg/L					
		A1	A2	A3	B1	B2	B3
Aerobic	0	7.84	8.83	8.99	9.71	9.34	9.47
	30	5.12	6.94	6.45	6.39	6.58	6.49
	60	4.63	6.39	5.80	5.61	5.88	5.69
	90	4.28	6.03	5.43	5.22	5.52	5.33
	120	4.01	5.74	5.12	4.89	5.22	5.06
	150	3.77	5.48	4.87	4.59	4.97	4.81
	180	3.54	5.26	4.65	4.33	4.74	4.59
	210	3.33	5.05	4.44	4.07	4.52	4.37
	240	3.12	4.84	4.25	3.83	4.30	4.17
	270	2.94	4.65	4.06	3.61	4.09	3.98
	300	2.76	4.46	3.89	3.40	3.90	3.79
	330	2.58	4.29	3.72	3.19	3.72	3.61
	360	2.43	4.11	3.55	2.99	3.54	3.44
	390	2.29	3.95	3.39	2.81	3.37	3.28
	420	2.15	3.80	3.24	2.63	3.21	3.12
	450	2.02	3.66	3.11	2.46	3.06	2.96
	480	1.91	3.52	2.99	2.29	2.89	2.81
	510	1.79	3.38	2.86	2.15	2.75	2.67
	540	1.69	3.25	2.74	2.00	2.61	2.54
	570	1.58	3.12	2.63	1.86	2.48	2.41
	600	1.49	3.01	2.52	1.73	2.36	2.28

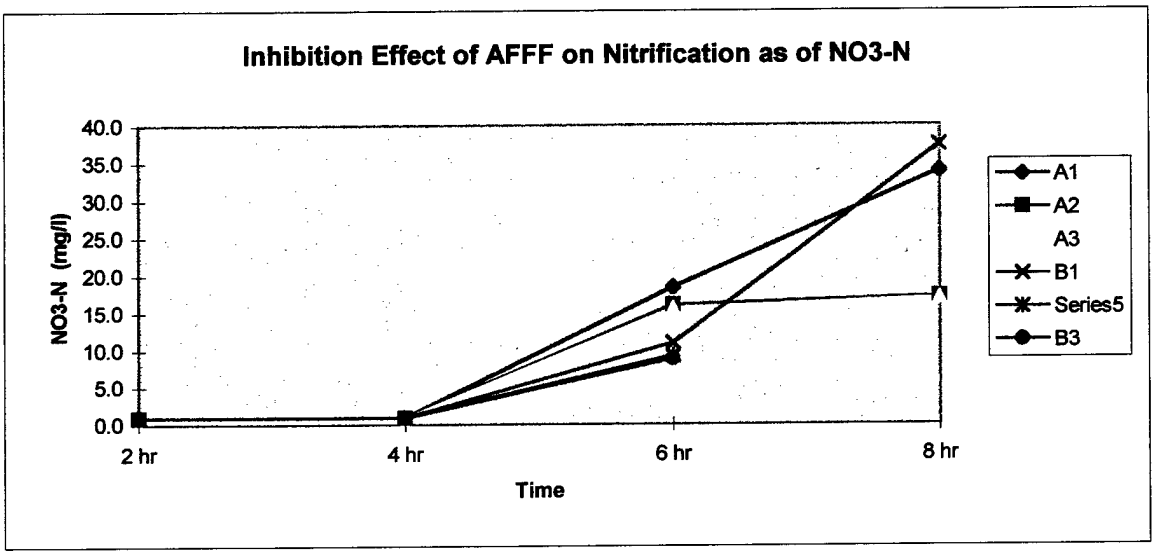
Date of Test: 3-25-97 | Concentrations Table | AFFF Conc. = 60 ppm

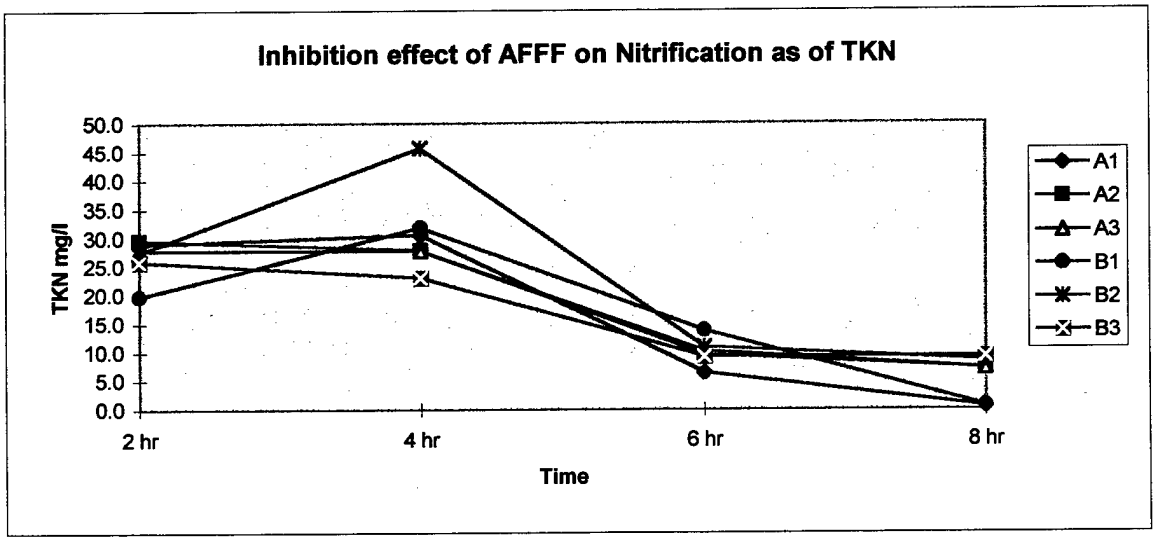
Reactor	AFFF (ppm)	H2O2 mg/l	Fe3+ mg/l	Stage	Time	Concentration, mg/L TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
				Feedstock		102.9	20.7	82.2	0.0	0.8	103.7	215.9	11.9
				RR Decant		2.2	0.4	1.8	-0.5	14.8	16.5	189.3	2.1
A1	0	0	0	End of Feeding	2 hr	28.8	20.7	8.1	0.0	0.8	29.6	201.4	30.3
				End of Anaerobic	4 hr	30.5	19.6	10.9	0.0	0.8	31.4	198.8	32.2
				End of Aerobic	6 hr	6.4	6.1	0.2	3.0	18.4	27.8	194.7	5.2
				Extended Aeration	(4hr)	1.5	0.1	1.4	-0.8	28.9	29.6	193.8	6.9
				End of Settling	8 hr	0.5	0.1	0.4	7.2	33.8	41.5	202.0	6.1
A2	0	0	0	End of Feeding	2 hr	29.5	20.7	8.9	0.0	0.8	30.4	201.4	22.8
				End of Anaerobic	4 hr	27.8	18.8	9.0	0.0	0.8	28.7	197.4	22.5
				End of Aerobic	6 hr	9.6	6.6	2.9	3.1	16.0	28.6	190.8	10.5
				End of Settling	8 hr	7.1	5.3	1.8	0.9	17.1	25.2	203.7	11.7
A3	0	0	0	End of Feeding	2 hr	27.8	19.9	8.0	0.0	0.8	28.7	197.9	15.1
				End of Anaerobic	4 hr	27.8	19.6	8.2	0.0	0.8	28.7	203.0	16.2
				End of Aerobic	6 hr	10.2	6.6	3.6	3.1	15.6	28.9	188.0	8.4
				End of Settling	8 hr	7.1	4.9	2.2	0.8	16.9	24.9	200.3	9.6
B1	60	3000	300	End of Feeding	2 hr	19.7	16.3	3.4	0.0	0.8	20.5	195.4	16.9
				End of Anaerobic	4 hr	31.8	15.4	16.4	0.0	0.8	32.6	200.0	19.4
				End of Aerobic	6 hr	13.7	7.5	6.3	3.3	10.9	28.0	186.4	12.1
				Extended Aeration	(4hr)	3.1	0.2	2.8	-0.2	23.2	26.0	189.7	11.2
				End of Settling	8 hr	0.6	0.1	0.5	0.0	37.4	38.0	198.9	12.2
B2	60	3000	300	End of Feeding	2 hr	27.4	16.3	11.1	0.0	0.8	28.2	196.3	12.7
				End of Anaerobic	4 hr	45.6	14.2	31.4	0.0	0.8	46.4	201.2	17.4
				End of Aerobic	6 hr	10.8	8.4	2.4	3.8	9.2	23.9	187.4	24.8
				End of Settling	8 hr	8.5	6.0	2.5	1.7	*	10.2	202.2	24.4
B3	60	3000	300	End of Feeding	2 hr	25.9	16.3	9.6	0.0	0.8	26.7	194.8	12.7
				End of Anaerobic	4 hr	23.0	15.4	7.6	-0.4	0.8	23.4	201.0	26.5
				End of Aerobic	6 hr	9.2	8.8	0.4	3.7	8.7	21.6	184.9	19.747
				End of Settling	8 hr	9.2	6.5	2.7	1.4	*	10.5	198.5	10.682

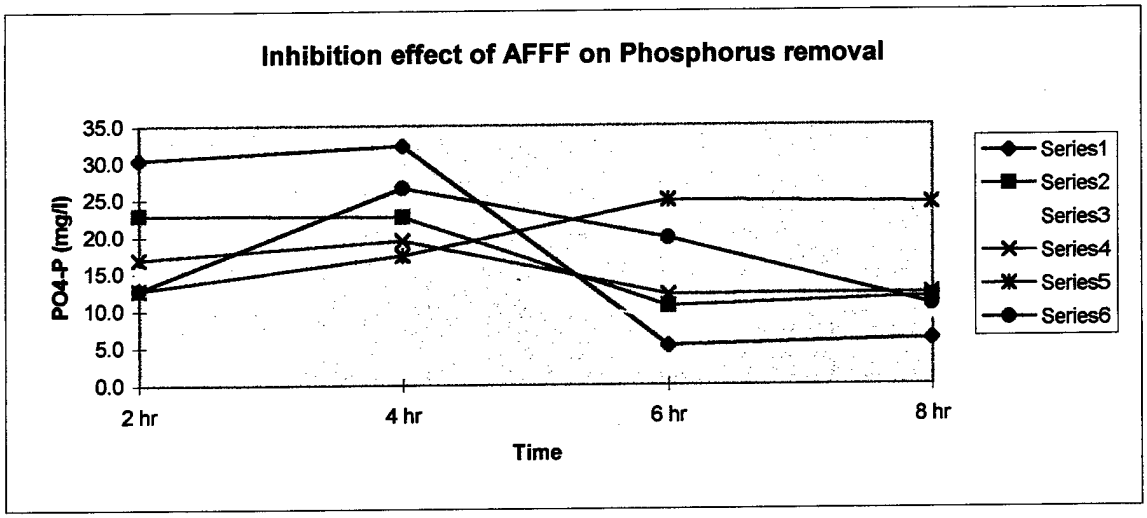
* Values not known

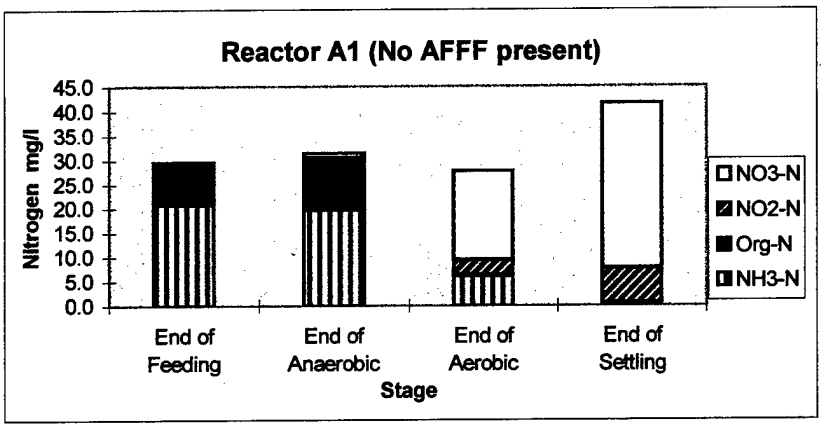
Reactor	AFFF (ppm)	Stage	Time	Concentration, mg/L BOD	COD	TOC	Alkalinity HCO3 (mg/l)
		Feedstock			973.5	406.6	447.0
		RR Decant			53.0	12.1	309.0
A1	0	End of Feeding	2 hr		76.1	**30.7**	498.0
		End of Anaerobic	4 hr		45.3	**19.5**	523.0
		End of Aerobic	6 hr		13.3	**14.8**	331.0
		Extended Aeration	(4hr)		13.3	**14.0**	263.0
		End of Settling	8 hr		26.5	**13.4**	262.0
A2	0	End of Feeding	2 hr		73.5	**28.6**	514.0
		End of Anaerobic	4 hr		53.0	**17.5**	480.0
		End of Aerobic	6 hr		39.8	**12.4**	337.0
		End of Settling	8 hr		26.5	**13.7**	327.0
A3	0	End of Feeding	2 hr		65.8	**28.4**	480.0
		End of Anaerobic	4 hr		58.1	**18.2**	500.0
		End of Aerobic	6 hr		26.5	**12.7**	328.0
		End of Settling	8 hr		13.3	**12.6**	331.0
B1	60	End of Feeding	2 hr		273.5	**85.2**	563.0
		End of Anaerobic	4 hr		242.7	**76.1**	534.0
		End of Aerobic	6 hr		132.7	**58.9**	411.0
		Extended Aeration	(4hr)		106.1	**58.0**	274.0
		End of Settling	8 hr		92.9	**60.0**	328.0
B2	60	End of Feeding	2 hr		288.9	**83.1**	590.0
		End of Anaerobic	4 hr		270.9	**76.1**	546.0
		End of Aerobic	6 hr		132.7	**59.4**	414.0
		End of Settling	8 hr		79.6	**59.8**	428.0
B3	60	End of Feeding	2 hr		314.5	**85.8**	553.0
		End of Anaerobic	4 hr		212.3	**77.7**	523.0
		End of Aerobic	6 hr		73	61.84	412
		End of Settling	8 hr		<5	62.23	437
		FS1				404.6	
		FS2				407.5	
		FS3				407.7	
		FS Avarage				406.6	
		RRSU1				12.9	
		RRSU2				11.3	
		RRSU3				12.0	
		RRSU Avarage				12.08	

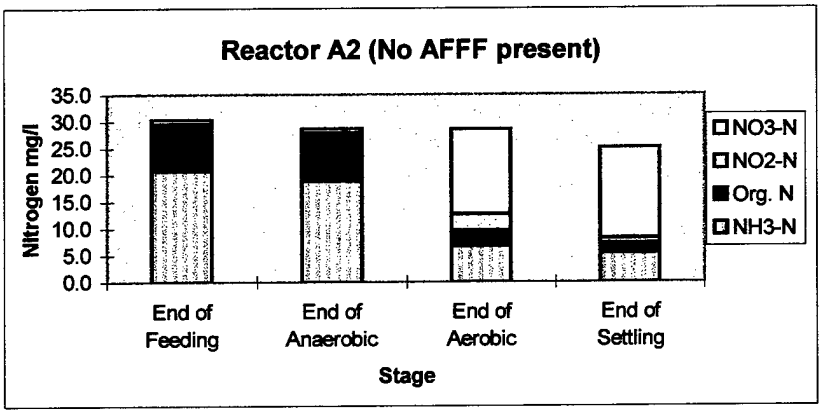

Inhibition Effect of AFFF on Nitrification in terms of NH3-N
NH3-N (mg/l)
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

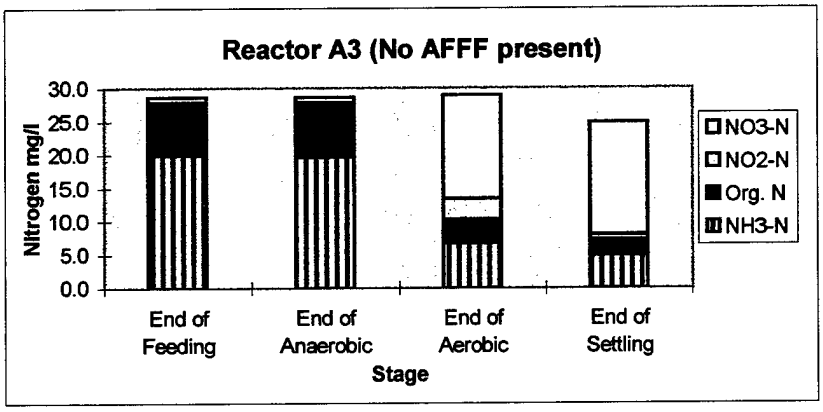

Inhibition Effect of AFFF on Nitrification as of NO3-N
NO3-N (mg/l)
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
Series5
B3

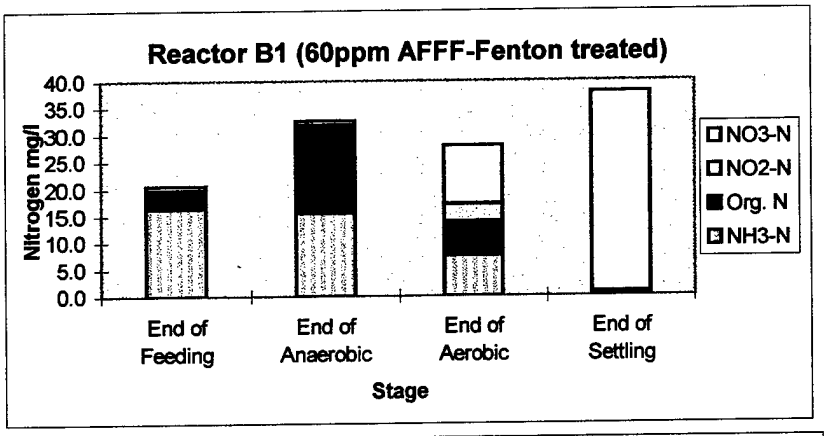

Inhibition effect of AFFF on Nitrification as of TKN
TKN mg/l
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

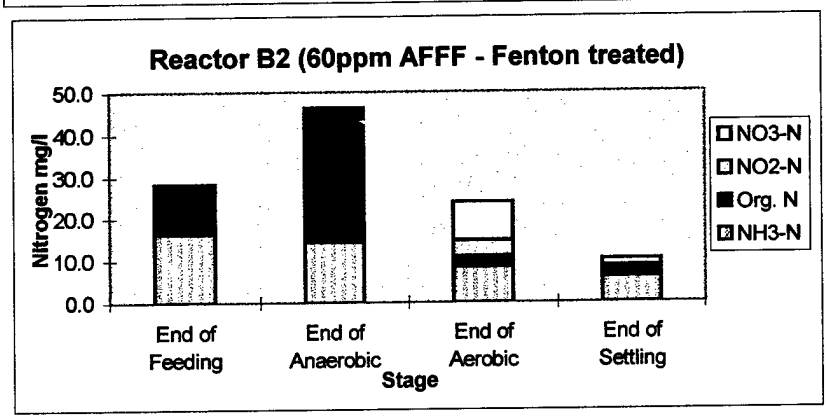

Inhibition effect of AFFF on Phosphorus removal
PO4-P (mg/l)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
Series1
Series2
Series3
Series4
Series5
Series6

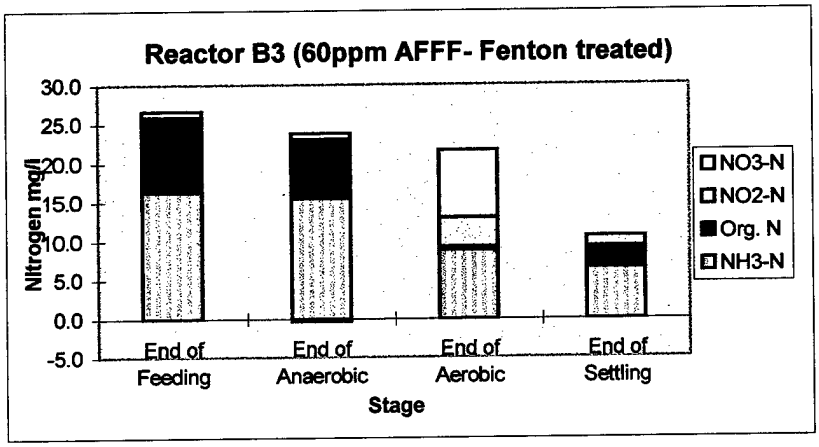

Reactor A1 (No AFFF present)
Nitrogen mg/l
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
NO3-N
NO2-N
Org-N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage


Reactor A2 (No AFFF present)
Nitrogen mg/l
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
NO3-N
NO2-N
Org. N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage


Reactor A3 (No AFFF present)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
NO3-N
NO2-N
Org. N
NH3-N
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage

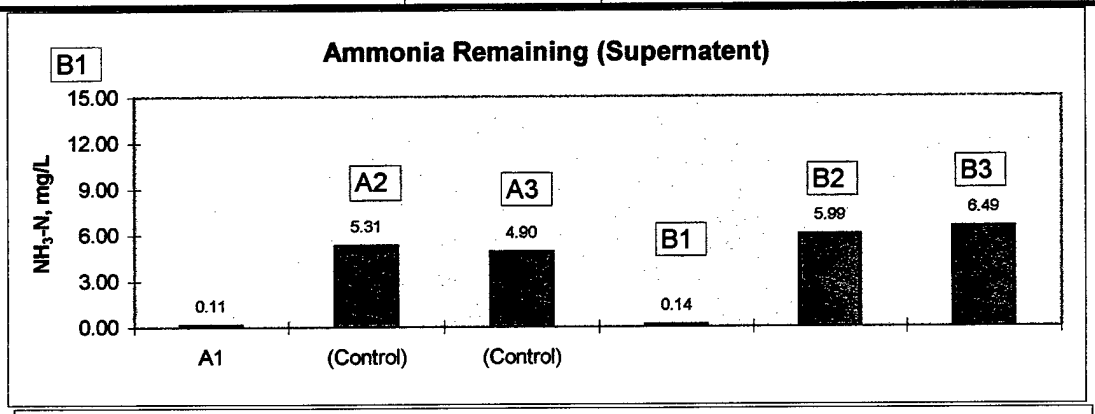

Reactor B1 (60ppm AFFF-Fenton treated)
Nitrogen mg/l
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

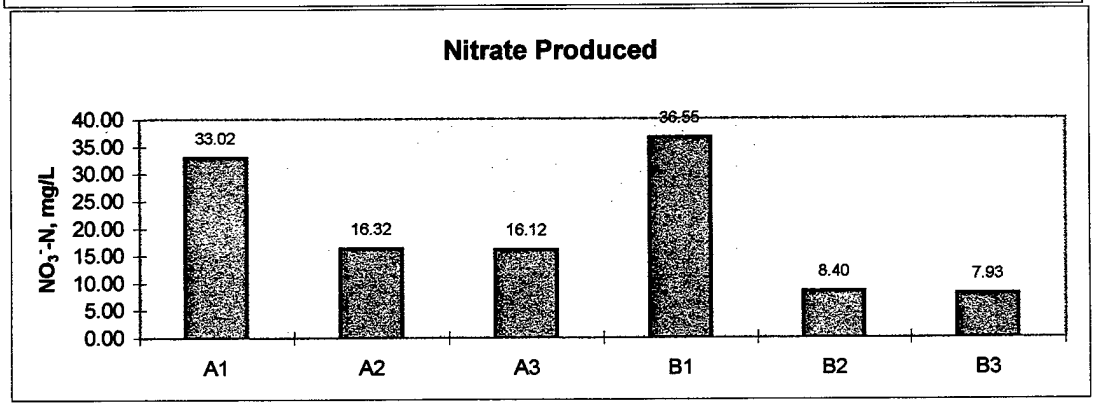

Reactor B2 (60ppm AFFF - Fenton treated)
Nitrogen mg/l
50.0
40.0
30.0
20.0
10.0
0.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N


Reactor B3 (60ppm AFFF- Fenton treated)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

Date of Test: 3-25-97 Inhibition Reactors / NO3- & NO2 Produced AFFF Conc. = 60 ppm

Reactor	AFFF ppm	H2O2 mg/l	Fe3+ mg/l	Stage	Time	Nitrogen Concentration, mg/L NH3-N	NO3--N	NO2--N	Δ(NO_3^--N)
A1	0	0	0	End of Feeding	2 hr	20.69	0.8	0.0	
(Control)				End of Anaerobic	4 hr	19.61	0.8	0.0	
				End of Aerobic	6 hr	6.11	18.4	3.0	
				Extended Aeration	(4hr)	0.11	28.9	-0.8	
				End of Settling	8 hr	0.11	33.8	7.2	33.02
A2	0	0	0	End of Feeding	2 hr	20.69	0.8	0.0	
(Control)				End of Anaerobic	4 hr	18.84	0.8	0.0	
				End of Aerobic	6 hr	6.62	16.0	3.1	
				End of Settling	8 hr	5.31	17.1	0.9	16.32
A3	0	0	0	End of Feeding	2 hr	19.88	0.8	0.0	
(Control)				End of Anaerobic	4 hr	19.61	0.8	0.0	
				End of Aerobic	6 hr	6.62	15.6	3.1	
				End of Settling	8 hr	4.90	16.9	0.8	16.12
B1	60	3000	300	End of Feeding	2 hr	16.26	0.8	0.0	
				End of Anaerobic	4 hr	15.42	0.8	0.0	
				End of Aerobic	6 hr	7.46	10.9	3.3	
				Extended Aeration	(4hr)	0.23	23.2	-0.2	
				End of Settling	8 hr	0.14	37.4	0.0	36.55
B2	60	3000	300	End of Feeding	2 hr	16.26	0.8	0.0	
				End of Anaerobic	4 hr	14.23	0.8	0.0	
				End of Aerobic	6 hr	8.42	9.2	3.8	
				End of Settling	8 hr	5.99	*	1.7	8.40
B3	60	3000	300	End of Feeding	2 hr	16.26	0.8	0.0	
				End of Anaerobic	4 hr	15.42	0.8	-0.4	
				End of Aerobic	6 hr	8.76	8.74	3.73	
				End of Settling	8 hr	6.49	*	1.36	7.93





File: AFFF Inhib (17-11-97).xls
Sheet: NO3- & NO2 Produced

BNR Inhibition Tests - 60 ppm AFFF Pretreated with Fenton's Reagent (Nov/17/97)

TSS Reactor	Initial wt	Final wt	Volume	MLSS	WT @ 550 C	MLVSS
A1	1.114	1.1559	15	2793	1.1187	2480
A2	1.1126	1.156	15	2893	1.1191	2460
A3	1.1199	1.162	15	2807	1.1255	2433
B1	1.1154	1.1586	15	2880	1.1154	2880
B2	1.1113	1.1527	15	2760	1.1172	2367
B3	1.0983	1.1394	15	2740	1.1025	2460

TDS Reactor	Initial wt	Final wt	Volume	TDS
A1	1.0134	1.0261	15	847
A2	1.0147	1.0293	15	973
A3	1.0153	1.0303	15	1000
B1	1.0436	1.0945	15	3393
B2	1.0465	1.0952	15	3247
B3	1.0307	1.0745	15	2920

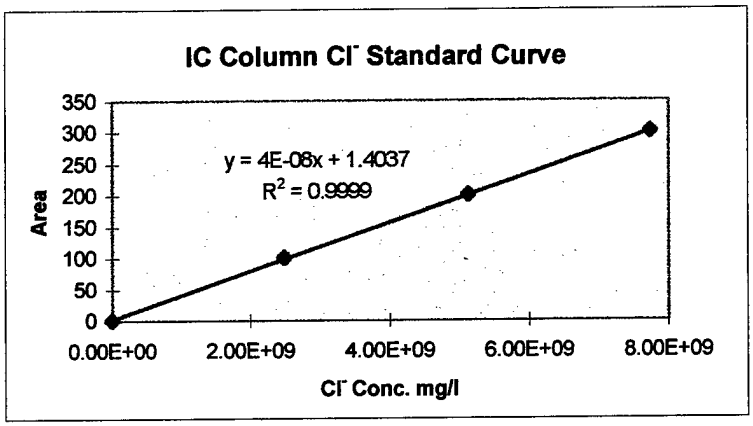
TS Reactor	Initial wt	Final wt	Volume	TS	ΣTSS,TDS
A1	1.0312	1.13	25	3952	3640
A2	1.0166	1.0746	15	3867	3867
A3	1.0122	1.0704	15	3880	3807
B1	1.0083	1.1003	15	6133	6273
B2	1.0141	1.1064	15	6153	6007
B3	1.0109	1.1044	15	6233	5660

BNR Inhibition Batch Assay Pretreated with Fenton's Reagent

(AFFF 120 ppm)

Reactor	AFFF (ppm)	H_2O_2 mg/l	Fe^{3+} mg/l	Stage	Time	NH3-N (mg/L)	TKN (mg/L)	Alkalinity
				Feedstock		34.6	140.7	430.0
				RR Decant		0.1	1.8	319.0
A1	0	0	0	End of Feeding	2 hr	25.2	16.2	501.0
				End of Anaerobic	4 hr	22.1	16.5	473.0
				End of Aerobic	6 hr	0.9	2.7	287.0
				Extended Aeration	(4hr)	0.1	2.6	297.0
				End of Settling	8 hr	0.1	2.0	271.0
A2	0	0	0	End of Feeding	2 hr	26.3	22.8	506.0
				End of Anaerobic	4 hr	21.3	23.3	484.0
				End of Aerobic	6 hr	1.0	2.9	273.0
				End of Settling	8 hr	0.5	2.8	291.0
A3	0	0	0	End of Feeding	2 hr	27.3	38.0	473.0
				End of Anaerobic	4 hr	18.9	27.6	487.0
				End of Aerobic	6 hr	1.0	2.9	294.0
				End of Settling	8 hr	0.5	5.6	300.0
B1	120	3000	300	End of Feeding	2 hr	27.3	50.6	592.0
				End of Anaerobic	4 hr	16.2	29.2	554.0
				End of Aerobic	6 hr	2.4	13.4	475.0
				Extended Aeration	(4hr)	0.1	5.9	457.0
				End of Settling	8 hr	0.1	8.7	433.0
B2	120	3000	300	End of Feeding	2 hr	24.3	42.6	584.0
				End of Anaerobic	4 hr	14.4	34.6	560.0
				End of Aerobic	6 hr	3.0	13.4	487.0
				End of Settling	8 hr	1.6	12.3	503.0
B3	120	3000	300	End of Feeding	2 hr	26.3	56.6	578.0
				End of Anaerobic	4 hr	14.4	41.1	564.0
				End of Aerobic	6 hr	2.9	12.0	485.0
				End of Settling	8 hr	1.6	9.8	477.0

Reactor	AFFF (ppm)	H_2O_2 mg/l	Fe^{3+} mg/l	Stage	Time	Cl- Area	Cl- (mg/L)	NO_2^--N Area	NO_2^--N (mg/L)	NO_3^--N Area	NO_3^--N (mg/L)	PO4-P Absorb.	PO4-P mg/l
				Feedstock		6415840997	249.5	0	0.0	2999602	0.9	0.359	11.37
				RR Decant		5165171073	201.1	15252495	0.4	980449999	17.4	0.11	3.94
A1	0	0	0	End of Feeding	2 hr	5636490017	219.3	0	0.0	8285053	1.0	0.556	17.24
				End of Anaerobic	4 hr	5565778827	216.6	22014912	0.5	8248297	1.0	1.527	46.20
				End of Aerobic	6 hr	5587767124	217.5	237912104	5.6	1309005030	22.9	0.196	6.51
				Extended Aeration	(4hr)	6360877548	247.3	28977091	0.7	1665166248	28.9	0.165	5.58
				End of Settling	8 hr	5742700331	223.4	14439043	0.3	1756232544	30.4	0.107	3.85
A2	0	0	0	End of Feeding	2 hr	5453642899	212.3	0	0.0	5348368	1.0	0.409	12.86
				End of Anaerobic	4 hr	5549230457	216.0	22476337	0.5	12719689	1.1	1.131	34.39
				End of Aerobic	6 hr	5545313287	215.8	243723873	5.7	1218372767	21.4	0.224	7.34
				End of Settling	8 hr	5663477238	220.4	253297426	5.9	1078852244	19.0	0.112	4.00
A3	0	0	0	End of Feeding	2 hr	5496024620	213.9	0	0.0	102182	0.9	1.03	31.38
				End of Anaerobic	4 hr	5576772514	217.0	21352132	0.5	9222295	1.0	1.194	36.27
				End of Aerobic	6 hr	5556863735	216.3	251352393	5.9	1228966969	21.6	0.099	3.61
				End of Settling	8 hr	5951069962	231.5	324595775	7.6	892540865	15.9	0.26	8.42
B1	120	3000	300	End of Feeding	2 hr	457079520	228.9	0	0.2	0	0.9	1.417	42.92
				End of Anaerobic	4 hr	436465012	219.4	0	0.2	2413048	0.9	1.52	45.99
				End of Aerobic	6 hr	424172102	213.7	25833324	7.3	56300488	21.9	1.172	35.61
				Extended Aeration	(4hr)	462727593	231.5	6404243	1.8	36280666	17.8	0.94	28.69
				End of Settling	8 hr	448160769	224.8	3939501	1.1	101580036	31.0	1.064	32.39
B2	120	3000	300	End of Feeding	2 hr	400203689	202.5	0	0.2	3064266	0.9	1.166	35.43
				End of Anaerobic	4 hr	395127891	200.2	0	0.2	3821042	0.9	1.669	50.43
				End of Aerobic	6 hr	408789981	206.5	28250426	7.9	46467575	19.9	1.102	33.52
				End of Settling	8 hr	459889036	230.2	5272664	1.5	89906486	28.6	1.074	32.69
B3	120	3000	300	End of Feeding	2 hr	412801655	208.4	0	0.2	5131448	1.0	1.105	33.61
				End of Anaerobic	4 hr	400870390	202.8	1322995	0.2	2745177	0.9	1.385	41.96
				End of Aerobic	6 hr	434292751	218.3	24585375	6.9	51478437	20.9	1.183	35.94
				End of Settling	8 hr	424292751	213.7	11525301	3.2	88687303	28.4	1.213	36.83
				stand 2		2501404503	98.12	434651899	10.18	506201128	9.39		
				Stand 3		5127125765	199.6	883978295	20.7	1094957038	19.3		
				stand 4		7886570017	306.3	1700383445	39.8	2399022283	41.2		
				Standards used									
				STD 1		1726964	0	0	0	2116836	0	0.158	5
				STD 2		2497916940	100	430009432	10	505155875	10	0.636	20
				STD 3		5128148989	200	883500936	20	1090488678	20	1.14	35
				STD 4		7744736801	300	1691875383	40	2354417370	40	1.666	50



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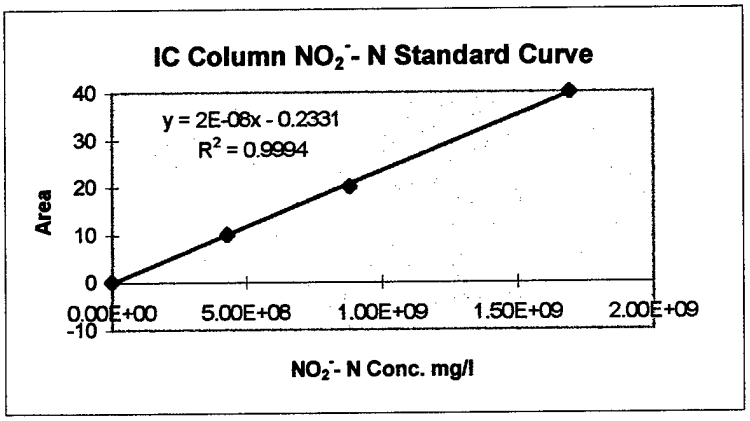

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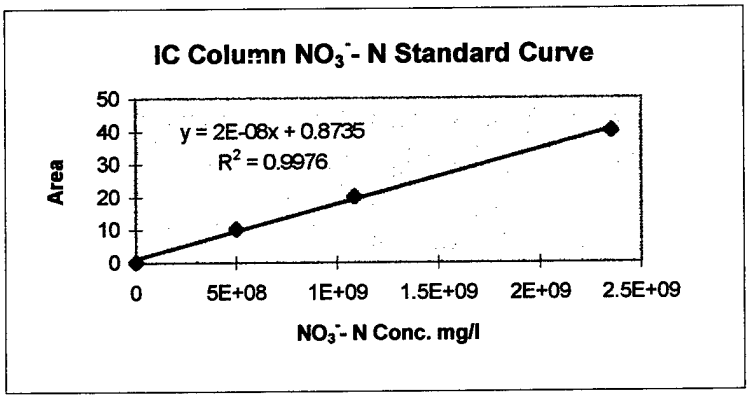

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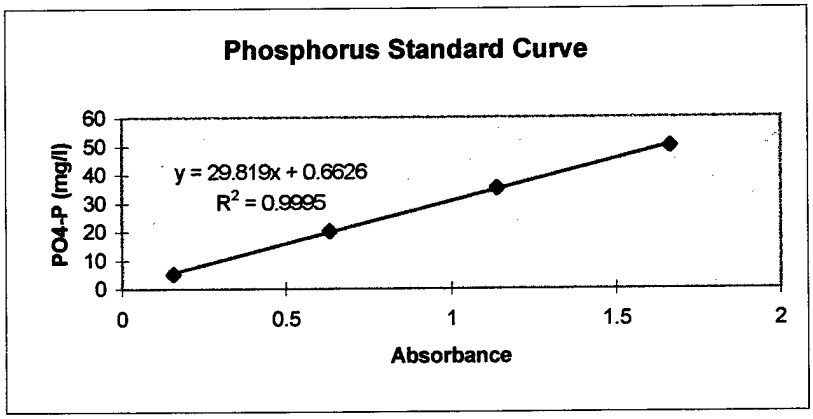


SUMMARY OUTPUT

CL

Regression Statistics	
R Square	0.999859016
Observations	4

	Coefficients	*Standard Error*
Intercept	1.403699417	1.56137508
X Variable 1	3.86654E-08	3.2466E-10

SUMMARY OUTPUT

NO2-N

Regression Statistics	
R Square	0.999387669
Observations	4

	Coefficients	*Standard Error*
Intercept	0	0.40411631
X Variable 1	2.34187E-08	4.131E-10

SUMMARY OUTPUT

NO3-N

Regression Statistics	
R Square	0.997641688
Observations	4

	Coefficients	*Standard Error*
Intercept	0.873456724	0.76464318
X Variable 1	1.68277E-08	5.7853E-10

SUMMARY OUTPUT

PO4-P

Regression Statistics	
R Square	0.999543893
Observations	4

	Coefficients	*Standard Error*
Intercept	0.6626043	0.47798482
X Variable 1	29.81932856	0.45041746

Reactor	AFFF (ppm)	H2O2 mg/l	Fe3+ mg/l	Stage	Time	COD ABS	COD (mg/L)	COD % COD Removal *
				Feedstock		0.080	**1082.4**	
				RR Decant		0.004	**54.1**	
A1	0	0	0	End of Feeding **	2 hr	0.002	**27.1**	93.2
				End of Anaerobic**	4 hr	0.001	**13.5**	96.6
				End of Aerobic	6 hr	0.005	**67.7**	83.0
				Extended Aeration	(4hr)	0.002	27.1	93.2
				End of Settling	8 hr	0.001	13.5	**96.6**
A2	0	0	0	End of Feeding**	2 hr	0.002	**27.1**	93.2
				End of Anaerobic **	4 hr	0.001	**13.5**	96.6
				End of Aerobic	6 hr	0.001	13.5	96.6
				End of Settling	8 hr	0.001	13.5	**96.6**
A3	0	0	0	End of Feeding**	2 hr	0.001	**13.5**	96.6
				End of Anaerobic**	4 hr	0.001	**13.5**	96.6
				End of Aerobic	6 hr	0.001	13.5	96.6
				End of Settling	8 hr	0.001	13.5	**96.6**
B1	120	3000	300	End of Feeding**	2 hr	0.029	**392.4**	**69.3**
				End of Anaerobic**	4 hr	0.029	**392.4**	69.3
				End of Aerobic	6 hr	0.027	365.3	71.4
				Extended Aeration	(4hr)	0.024	324.7	74.6
				End of Settling	8 hr	0.025	338.3	**73.5**
B2	120	3000	300	End of Feeding**	2 hr	0.028	**378.8**	70.3
				End of Anaerobic**	4 hr	0.040	**541.2**	57.6
				End of Aerobic	6 hr	0.024	324.7	74.6
				End of Settling	8 hr	0.024	324.7	**74.6**
B3	120	3000	300	End of Feeding**	2 hr	0.026	**351.8**	72.4
				End of Anaerobic	4 hr	0.023	**311.2**	75.6
				End of Aerobic	6 hr	0.021	284.1	77.7
				End of Settling	8 hr	0.021	284.1	**77.7**
				STD 1		0.000	0	
				STD 2		0.077	1000	
				STD 3		0.147	2000	
				STD 4		0.225	3000	
				STD 5		0.330	4500	
				FS (Filtered)**		0.080	1082.4	
				FS Average**		**0.080**	**1082.4**	
				RRSU(Filtered)**		0.004	**54.1**	
				RRSU Average**		**0.004**	**54.1**	

* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.

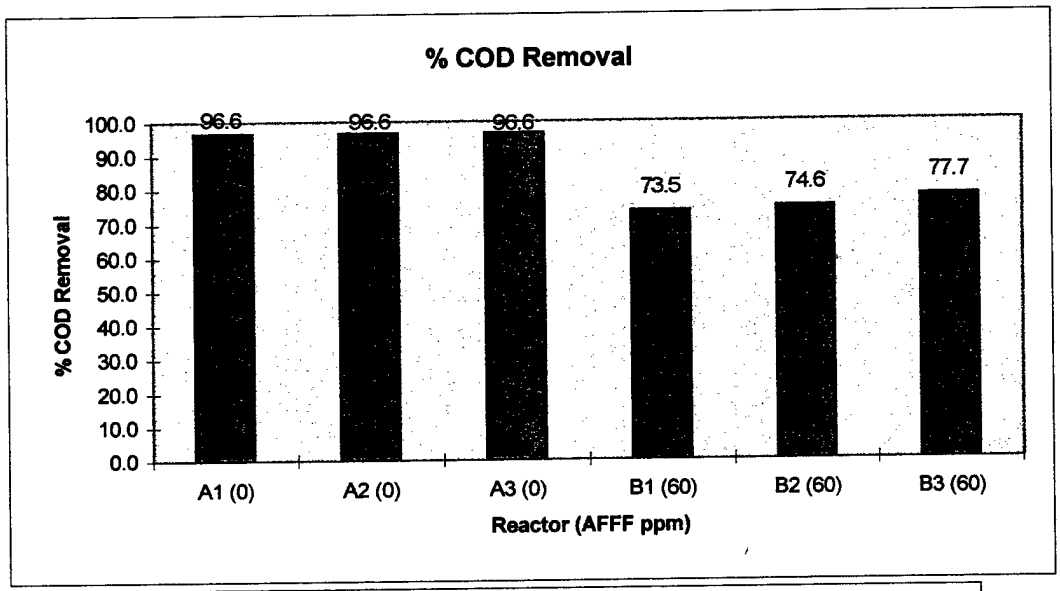
Initial COD at Time 0 hr.

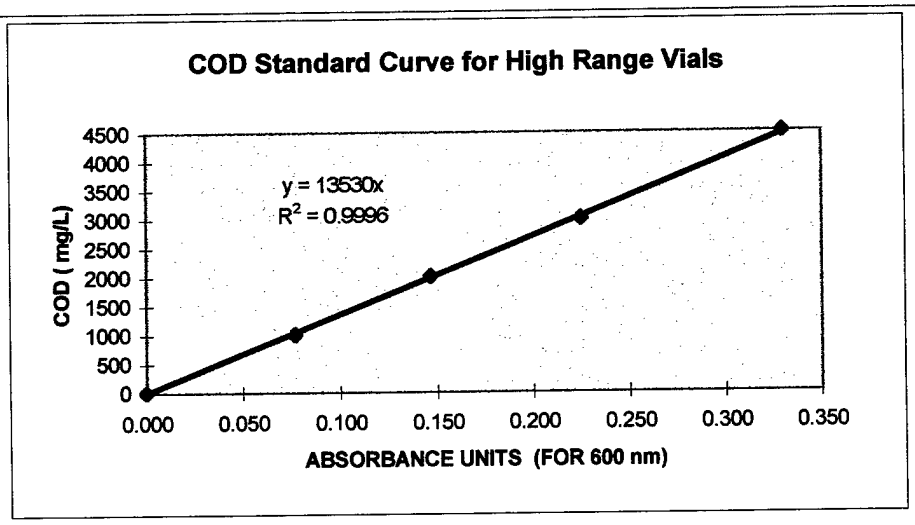
Sample	Constituent	Vol (L)	COD mg/L	
Controls	RR Decant	4	54.1	216.48
(A1,A2&A3)	Feedstock	2	1082.4	2164.8
	AFFF	0	0	0
	Total	6		**396.9**
Inhibition	RR Decant	4	54.1	216.48
(B1,B2&B3)	Feedstock	2	1082.4	2164.8
	AFFF	2	2638.35	5276.7
	Total	6		**1276.3**

Raw AFFF COD Reduced by Fentons Reagent

Total

Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (60)	B2 (60)	B3 (60)
% COD Removal	96.6	96.6	96.6	73.5	74.6	77.7





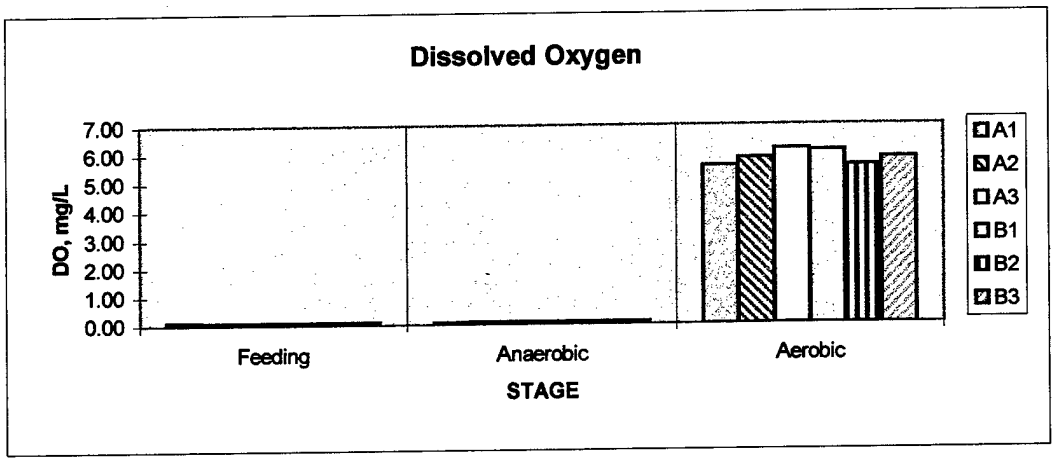
m = *13530*

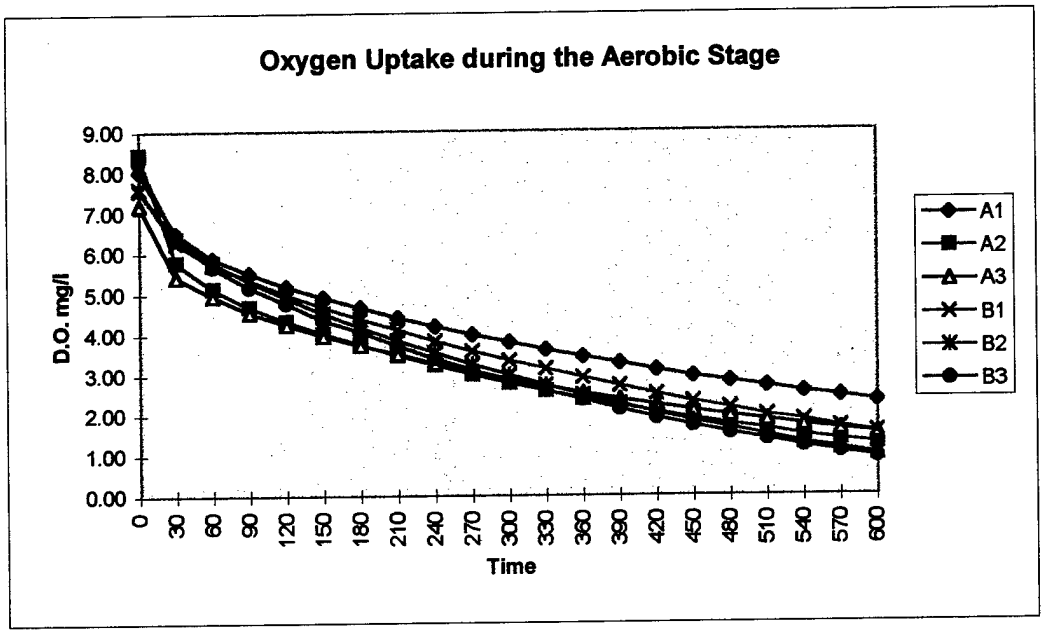
Fentons Pretreatment			
For AFFF ppm	120	120	120
	Reactor 1	Reactor 2	Reactor 3
Tap water	1250 ml	1250 ml	1250 ml
Actual AFFF ppm	300	300	300
	10 ml	10 ml	10 ml
H202, 3000*2.5 mg/l	7500 mg/l	7500 mg/l	7500mg/l
Fe3+ 300*2.5	750 mg/l	750 mg/l	750 mg/l
FeSO4 (3times)	3723.28 mg/l	3723.28 mg/l	3723.28 mg/l

Initial COD			
	Absorbance	COD mg/l	Actual COD
AFFF - 120 ppm	0.251	3396.03	3396.03

COD after 24 hr reaction period between fentons reagent and AFFF

	Absorbance	COD mg/l	Actual COD
	0.195	2638.35	2638.35
% COD Removal	22.31		


Dissolved Oxygen
DO, mg/L
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3


Oxygen Uptake during the Aerobic Stage
D.O. mg/l
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
Time
A1
A2
A3
B1
B2
B3

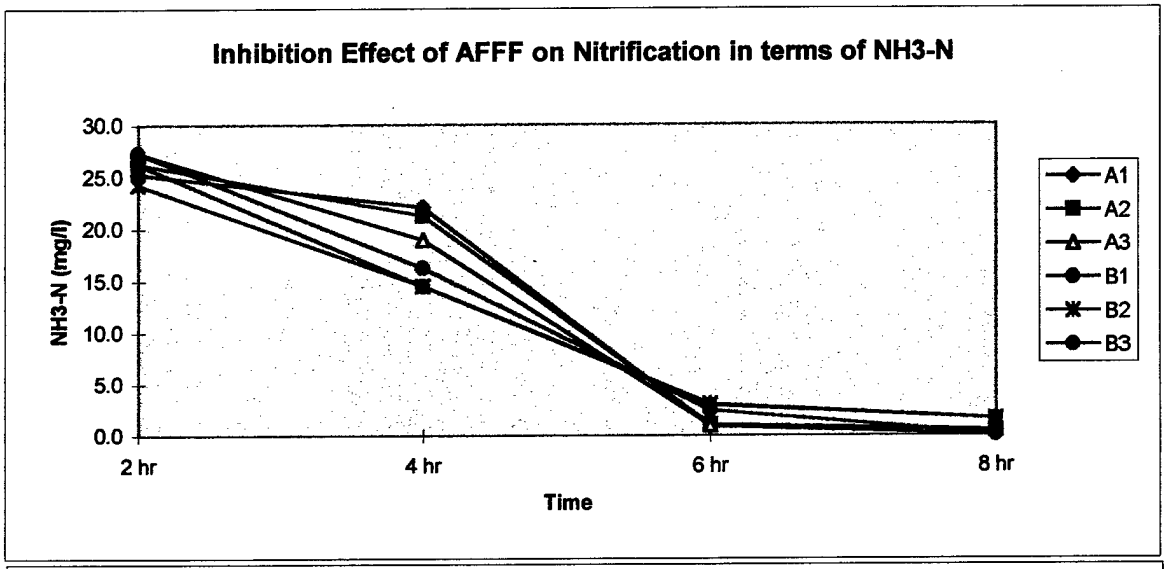
	Dissolved Oxygen (mg/L) at various stages					
Stage	A1	A2	A3	B1	B2	B3
Feeding	0.11	0.09	0.09	0.09	0.08	0.10
Anaerobic	0.07	0.08	0.09	0.09	0.10	0.09
Aerobic	5.58	5.84	6.17	6.10	5.57	5.85

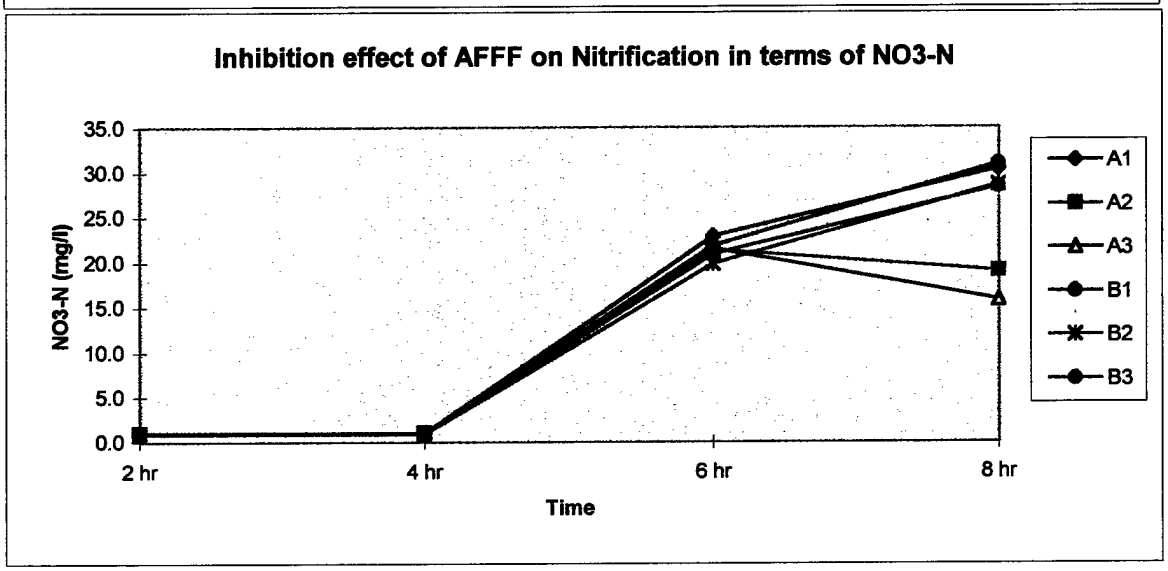
		Dissolved Oxygen in mg/L					
Stage	Time (sec)	A1	A2	A3	B1	B2	B3
Aerobic	0	8.02	8.43	7.20	7.61	7.56	8.25
	30	6.49	5.77	5.42	6.26	6.37	6.38
	60	5.86	5.12	4.96	5.72	5.77	5.66
	90	5.50	4.68	4.54	5.35	5.31	5.16
	120	5.18	4.32	4.25	4.98	4.90	4.76
	150	4.90	4.02	3.97	4.67	4.52	4.35
	180	4.66	3.74	3.73	4.37	4.17	4.06
	210	4.40	3.47	3.51	4.11	3.84	3.71
	240	4.18	3.23	3.27	3.83	3.54	3.39
	270	3.98	2.99	3.07	3.58	3.25	3.11
	300	3.79	2.77	2.88	3.34	2.98	2.83
	330	3.60	2.58	2.71	3.13	2.73	2.59
	360	3.43	2.38	2.54	2.91	2.48	2.36
	390	3.27	2.22	2.39	2.72	2.26	2.13
	420	3.10	2.05	2.24	2.51	2.04	1.92
	450	2.95	1.89	2.10	2.32	1.84	1.72
	480	2.83	1.75	1.97	2.16	1.66	1.54
	510	2.69	1.63	1.86	1.98	1.48	1.38
	540	2.56	1.48	1.74	1.85	1.29	1.21
	570	2.44	1.37	1.63	1.68	1.15	1.06
	600	2.32	1.27	1.54	1.55	1.01	0.92

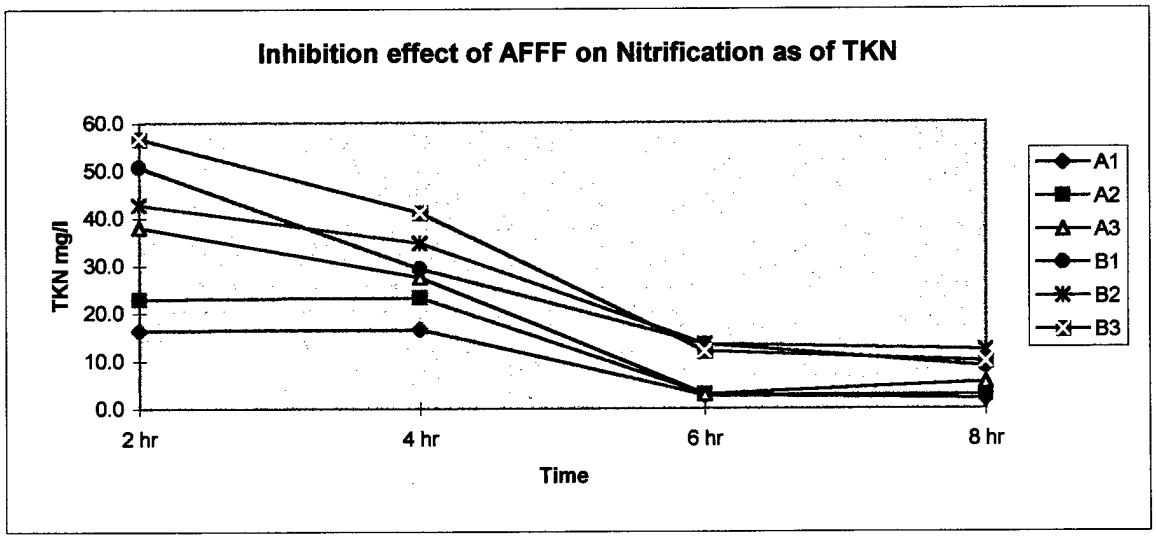
Reactor	AFFF (ppm)	H2O2 mg/l	Fe3+ mg/l	Stage	Time	Concentration, mg/L							
						TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
				Feedstock		140.7	34.6	106.0	0.0	0.9	141.6	249.5	11.4
				RR Decant		1.8	0.1	1.7	0.4	17.4	19.5	201.1	3.9
A1	0	0	0	End of Feeding	2 hr	16.2	25.2	-9.0	0.0	1.0	17.2	219.3	17.2
				End of Anaerobic	4 hr	16.5	22.1	-5.6	0.5	1.0	18.0	216.6	46.2
				End of Aerobic	6 hr	2.7	0.9	1.9	5.6	22.9	31.2	217.5	6.5
				Extended Aeration	(4hr)	2.6	0.1	2.5	0.7	28.9	32.2	247.3	5.6
				End of Settling	8 hr	2.0	0.1	1.9	0.3	30.4	32.8	223.4	3.9
A2	0	0	0	End of Feeding	2 hr	22.8	26.3	-3.5	0.0	1.0	23.8	212.3	12.9
				End of Anaerobic	4 hr	23.3	21.3	2.0	0.5	1.1	24.9	216.0	34.4
				End of Aerobic	6 hr	2.9	1.0	1.9	5.7	21.4	30.0	215.8	7.3
				End of Settling	8 hr	2.8	0.5	2.3	5.9	19.0	27.8	220.4	4.0
A3	0	0	0	End of Feeding	2 hr	38.0	27.3	10.7	0.0	0.9	38.9	213.9	31.4
				End of Anaerobic	4 hr	27.6	18.9	8.7	0.5	1.0	29.1	217.0	36.3
				End of Aerobic	6 hr	2.9	1.0	1.9	5.9	21.6	30.3	216.3	3.6
				End of Settling	8 hr	5.6	0.5	5.1	7.6	15.9	29.1	231.5	8.4
B1	120	3000	300	End of Feeding	2 hr	50.6	27.3	23.3	0.2	0.9	51.6	228.9	42.9
				End of Anaerobic	4 hr	29.2	16.2	13.0	0.2	0.9	30.3	219.4	46.0
				End of Aerobic	6 hr	13.4	2.4	11.0	7.3	21.9	42.5	213.7	35.6
				Extended Aeration	(4hr)	5.9	0.1	5.8	1.8	17.8	25.5	231.5	28.7
				End of Settling	8 hr	8.7	0.1	8.6	1.1	31.0	40.8	224.8	32.4
B2	120	3000	300	End of Feeding	2 hr	42.6	24.3	18.4	0.2	0.9	43.8	202.5	35.4
				End of Anaerobic	4 hr	34.6	14.4	20.2	0.2	0.9	35.8	200.2	50.4
				End of Aerobic	6 hr	13.4	3.0	10.4	7.9	19.9	41.2	206.5	33.5
				End of Settling	8 hr	12.3	1.6	10.6	1.5	28.6	42.4	230.2	32.7
B3	120	3000	300	End of Feeding	2 hr	56.6	26.3	30.4	0.2	1.0	57.8	208.4	33.6
				End of Anaerobic	4 hr	41.1	14.4	26.7	0.2	0.9	42.2	202.8	42.0
				End of Aerobic	6 hr	12.0	2.9	9.1	6.9	20.9	39.8	218.3	35.939
				End of Settling	8 hr	9.8	1.6	8.2	3.2	28.4	41.4	213.7	36.833

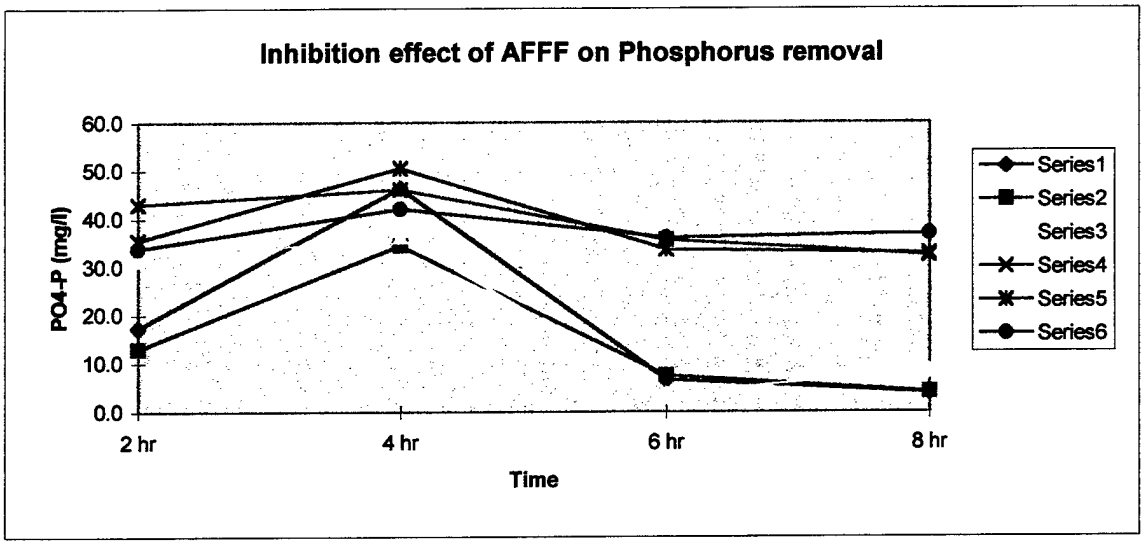
Reactor	AFFF (ppm)	Stage	Time	Concentration, mg/L BOD	COD	TOC	Alkalinity HCO3 (mg/l)
		Feedstock			1082.4	287.7	430.0
		RR Decant			54.1	11.5	319.0
A1	0	End of Feeding	2 hr		27.1	**12.6**	501.0
		End of Anaerobic	4 hr		13.5	13.29	473.0
		End of Aerobic	6 hr		67.7	11.48	287.0
		Extended Aeration	(4hr)		27.1	11.34	297.0
		End of Settling	8 hr		13.5	**11.5**	271.0
A2	0	End of Feeding	2 hr		27.1	**12.8**	506.0
		End of Anaerobic	4 hr		13.5	13.26	484.0
		End of Aerobic	6 hr		13.5	**11.6**	273.0
		End of Settling	8 hr		13.5	**11.5**	291.0
A3	0	End of Feeding	2 hr		13.5	**10.6**	473.0
		End of Anaerobic	4 hr		13.5	**11.7**	487.0
		End of Aerobic	6 hr		13.5	**11.1**	294.0
		End of Settling	8 hr		13.5	**11.4**	300.0
B1	120	End of Feeding	2 hr		392.4	**140.5**	592.0
		End of Anaerobic	4 hr		392.4	**125.8**	554.0
		End of Aerobic	6 hr		365.3	**135.7**	475.0
		Extended Aeration	(4hr)		324.7	**131.9**	457.0
		End of Settling	8 hr		338.3	**133.2**	433.0
B2	120	End of Feeding	2 hr		378.8	**155.9**	584.0
		End of Anaerobic	4 hr		541.2	**131.5**	560.0
		End of Aerobic	6 hr		324.7	**122.5**	487.0
		End of Settling	8 hr		324.7	**122.4**	503.0
B3	120	End of Feeding	2 hr		351.8	**161.2**	578.0
		End of Anaerobic	4 hr		311.2	**138.5**	564.0
		End of Aerobic	6 hr		263.3	139.2	485
		End of Settling	8 hr		263.3	132.0	477
		FS1				287.1	
		FS2				288.9	
		FS3				287.1	
		FS Avarage				287.7	
		RRSU1				12.0	
		RRSU2				11.2	
		RRSU3				11.3	
		RRSU Avarage				11.48	

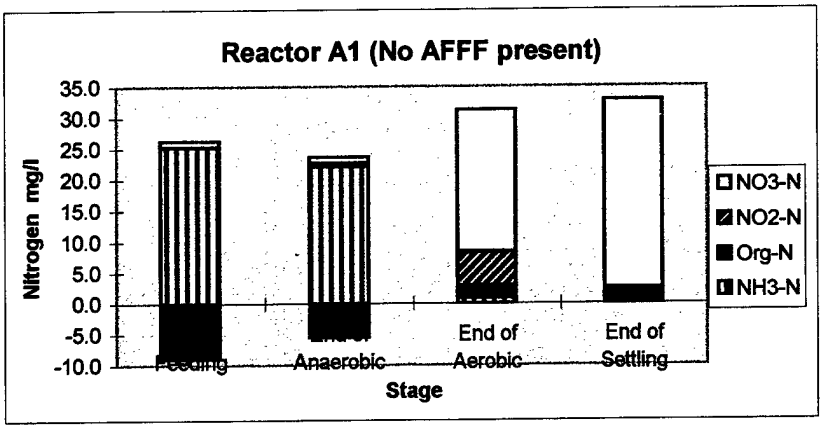
AFFF 120 ppm.

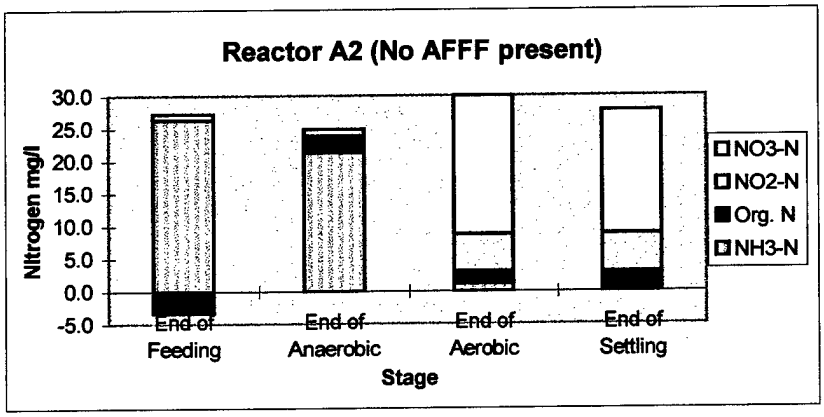

Inhibition Effect of AFFF on Nitrification in terms of NH3-N
NH3-N (mg/l)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

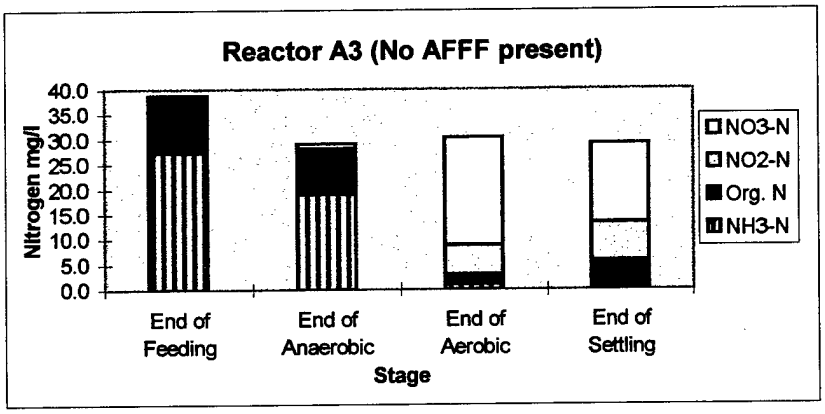

Inhibition effect of AFFF on Nitrification in terms of NO3-N
NO3-N (mg/l)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

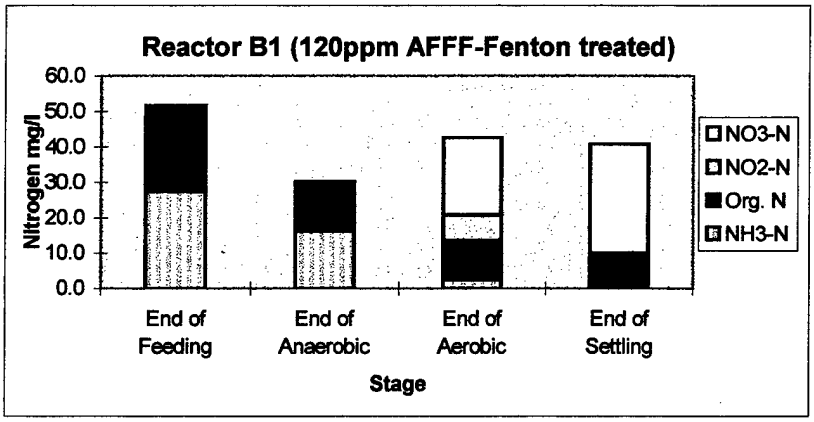

Inhibition effect of AFFF on Nitrification as of TKN
TKN mg/l
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

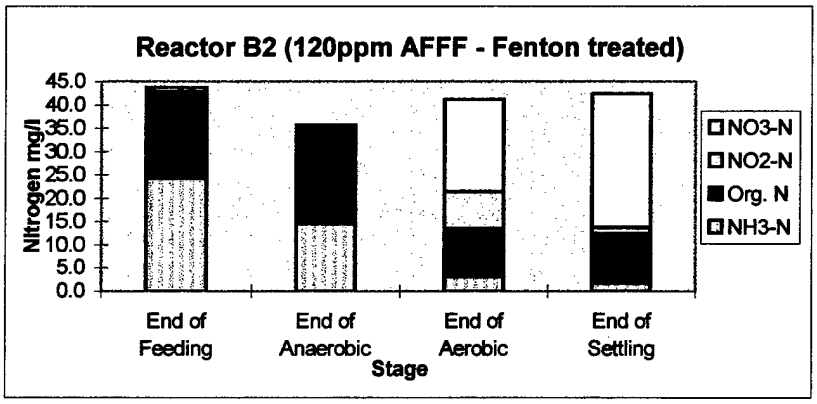

Inhibition effect of AFFF on Phosphorus removal
60.0
50.0
40.0
30.0
20.0
10.0
0.0
PO4-P (mg/l)
2 hr
4 hr
6 hr
8 hr
Time
Series1
Series2
Series3
Series4
Series5
Series6

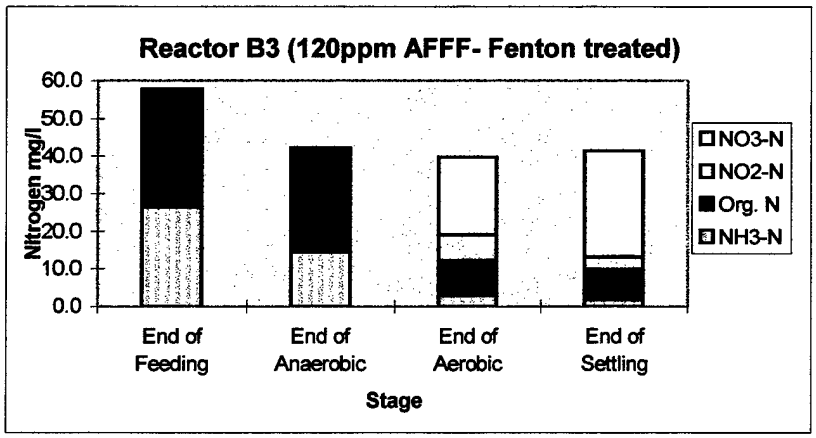

Reactor A1 (No AFFF present)
Nitrogen mg/l
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
Feeding
Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org-N
NH3-N


Reactor A2 (No AFFF present)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

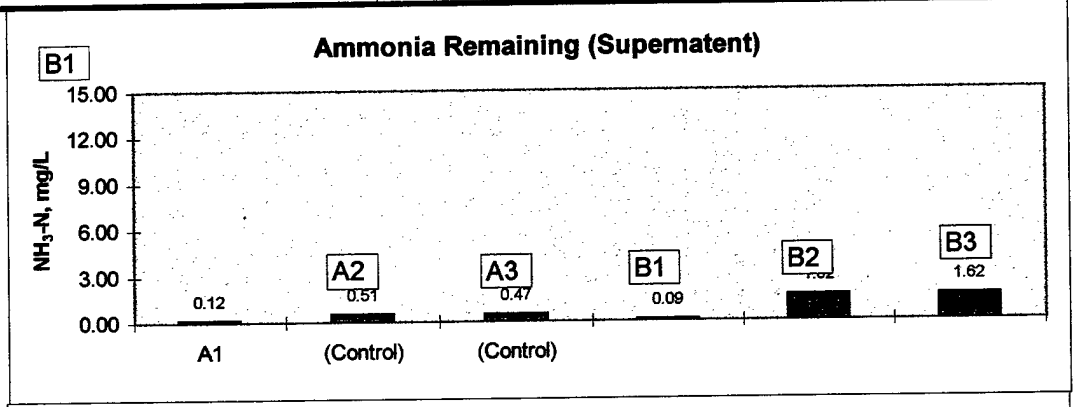

Reactor A3 (No AFFF present)
Nitrogen mg/l
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

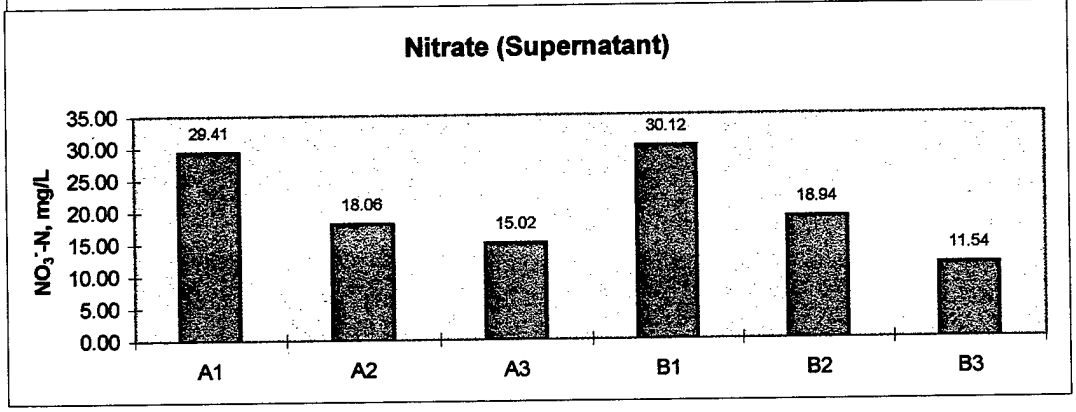

Reactor B1 (120ppm AFFF-Fenton treated)
Nitrogen mg/l
60.0
50.0
40.0
30.0
20.0
10.0
0.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N


Reactor B2 (120ppm AFFF - Fenton treated)
Nitrogen mg/l
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N


Reactor B3 (120ppm AFFF- Fenton treated)
Nitrogen mg/l
60.0
50.0
40.0
30.0
20.0
10.0
0.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

Reactor	AFFF ppm	H2O2 mg/l	Fe3+ mg/l	Stage	Time	Nitrogen Concentration, mg/L NH3-N	NO3--N	NO2--N	Δ(NO_3^--N)
A1 (Control)	0	0	0	End of Feeding	2 hr	25.23	1.0	0.0	
				End of Anaerobic	4 hr	22.10	1.0	0.5	
				End of Aerobic	6 hr	0.85	22.9	5.6	
				Extended Aeration	(4hr)	0.12	28.9	0.7	
				End of Settling	8 hr	0.07	30.4	0.3	29.41
A2 (Control)	0	0	0	End of Feeding	2 hr	26.25	1.0	0.0	
				End of Anaerobic	4 hr	21.26	1.1	0.5	
				End of Aerobic	6 hr	1.03	21.4	5.7	
				End of Settling	8 hr	0.51	19.0	5.9	18.06
A3 (Control)	0	0	0	End of Feeding	2 hr	27.31	0.9	0.0	
				End of Anaerobic	4 hr	18.93	1.0	0.5	
				End of Aerobic	6 hr	0.99	21.6	5.9	
				End of Settling	8 hr	0.47	15.9	7.6	15.02
B1	120	3000	300	End of Feeding	2 hr	27.30	0.9	0.2	
				End of Anaerobic	4 hr	16.22	0.9	0.2	
				End of Aerobic	6 hr	2.41	21.9	7.3	
				Extended Aeration	(4hr)	0.10	17.8	1.8	
				End of Settling	8 hr	0.09	31.0	1.1	30.12
B2	120	3000	300	End of Feeding	2 hr	24.25	0.9	0.2	
				End of Anaerobic	4 hr	14.44	0.9	0.2	
				End of Aerobic	6 hr	3.04	19.9	7.9	
				End of Settling	8 hr	1.62	28.6	1.5	18.94
B3	120	3000	300	End of Feeding	2 hr	26.25	1.0	0.2	
				End of Anaerobic	4 hr	14.44	0.9	0.2	
				End of Aerobic	6 hr	2.92	12.50	4.17	
				End of Settling	8 hr	1.62	14.01	0.47	11.54





BNR Inhibition Tests - 120 ppm AFFF with Fenton's Treatment (Dec/1/97)

TSS Reactor	Initial wt	Final wt	Volume	MLSS	WT @ 550 C	MLVSS
A1	1.0941	1.1387	15	2973	1.0993	2627
A2	1.0988	1.1444	15	3040	1.1035	2727
A3	1.0985	1.1424	15	2927	1.1028	2640
B1	1.0895	1.133	15	2900	1.0933	2647
B2	1.0905	1.1346	15	2940	1.0948	2653
B3	1.0951	1.1371	15	2800	1.1	2473

TDS Reactor	Initial wt	Final wt	Volume	TDS
A1	1.0026	1.0181	15	1033
A2	1.0032	1.0186	15	1027
A3	0.9989	1.0134	15	967
B1	1.0095	1.073	15	4233
B2	1.0013	1.0626	15	4087
B3	0.9993	1.05	15	3380

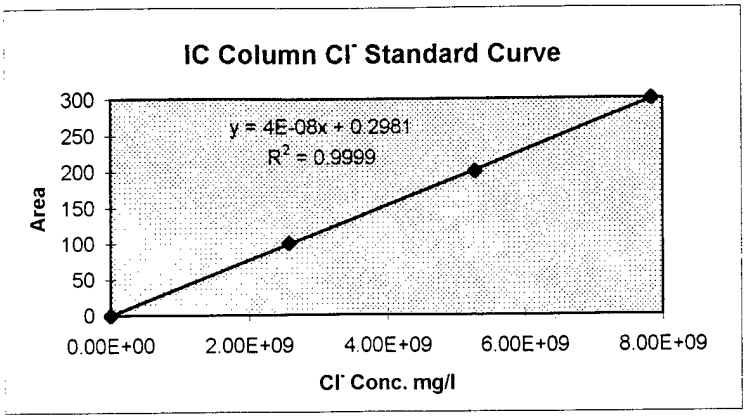
TS Reactor	Initial wt	Final wt	Volume	TS	ΣTSS,TDS
A1	1.0128	1.0728	15	4000	4007
A2	1.0051	1.0646	15	3967	4067
A3	0.9958	1.0556	15	3987	3893
B1	1.0042	1.1127	15	7233	7133
B2	0.9972	1.1077	15	7367	7027
B3	0.9995	1.1048	15	7020	6180

BNR Inhibition Batch Assay Pretreated with Fenton's Reagent

(AFFF 480 ppm)

Reactor	AFFF (ppm)	H_2O_2 mg/l	Fe^{3+} mg/l	Stage	Time	NH3-N (mg/L)	TKN (mg/L)	Alkalinity
				Feedstock		**23.3**	**39.2**	**510.0**
				RR Decant		**0.2**	**1.5**	**300.0**
A1	0	0	0	End of Feeding	2 hr	**18.3**	**15.3**	**533.0**
				End of Anaerobic	4 hr	**20.8**	**18.1**	**557.0**
				End of Aerobic	6 hr	**7.1**	**3.7**	**371.0**
				Extended Aeration	(4hr)	**0.2**	**0.7**	**273.0**
				End of Settling	8 hr	**0.1**	**2.1**	**267.0**
A2	0	0	0	End of Feeding	2 hr	**17.6**	**14.4**	**520.0**
				End of Anaerobic	4 hr	**20.0**	**15.2**	**547.0**
				End of Aerobic	6 hr	**8.3**	**2.4**	**407.0**
				End of Settling	8 hr	**5.8**	**5.3**	**367.0**
A3	0	0	0	End of Feeding	2 hr	**17.6**	**14.4**	**527.0**
				End of Anaerobic	4 hr	**20.0**	**15.2**	**521.0**
				End of Aerobic	6 hr	**9.4**	**3.9**	**397.0**
				End of Settling	8 hr	**6.2**	**5.7**	**373.0**
B1	480	3000	300	End of Feeding	2 hr	**15.0**	**13.6**	**577.0**
				End of Anaerobic	4 hr	**16.4**	**13.5**	**548.0**
				End of Aerobic	6 hr	**14.6**	**11.8**	**567.0**
				Extended Aeration	(4hr)	**10.1**	**12.5**	**504.0**
				End of Settling	8 hr	**6.8**	**9.0**	**477.0**
B2	480	3000	300	End of Feeding	2 hr	**15.0**	**12.8**	**593.0**
				End of Anaerobic	4 hr	**16.4**	**13.5**	**564.0**
				End of Aerobic	6 hr	**14.6**	**12.5**	**550.0**
				End of Settling	8 hr	**9.3**	**16.1**	**534.0**
B3	480	3000	300	End of Feeding	2 hr	**14.4**	**13.6**	**577.0**
				End of Anaerobic	4 hr	**15.8**	**15.2**	**542.0**
				End of Aerobic	6 hr	**15.1**	**11.1**	**555.0**
				End of Settling	8 hr	**9.7**	**12.8**	**620.0**

Reactor	AFFF (ppm)	H_2O_2 mg/l	Fe^{3+} mg/l	Stage	Time	Cl- Area	Cl- (mg/L)	NO_2^--N Area	NO_2^--N (mg/L)	NO_3^--N Area	NO_3^--N (mg/L)	PO4-P Absorb.	PO4-P mg/l
				Feedstock		6994915305	267.2	0	0.0	6898590	0.9	0.366	11.46
				RR Decant		6143498102	234.7	0	0.0	152448200	3.4	0.057	2.06
A1	0	0	0	End of Feeding	2 hr	6342217404	242.3	0	0.0	16135853	1.1	0.889	27.39
				End of Anaerobic	4 hr	6314295331	241.3	16684479	0.4	340286209	6.5	1.067	32.80
				End of Aerobic	6 hr	6564722520	250.8	207690276	4.8	1029993807	18.1	0.195	6.26
				Extended Aeration	(4hr)	6360877548	243.0	28977091	0.7	1665166248	28.8	0.107	3.58
				End of Settling	8 hr	6442995920	246.2	0	0.0	1774355893	30.7	0.026	1.11
A2	0	0	0	End of Feeding	2 hr	6295388362	240.5	0	0.0	7701686	0.9	1.129	34.69
				End of Anaerobic	4 hr	6281276851	240.0	0	0.0	5558668	0.9	1.265	38.83
				End of Aerobic	6 hr	6463991289	247.0	224767195	5.2	756122193	13.5	0.324	10.19
				End of Settling	8 hr	6324538637	241.6	200313133	4.6	776512216	13.9	0.145	4.74
A3	0	0	0	End of Feeding	2 hr	6404002120	244.7	0	0.0	4154920	0.9	1.041	32.01
				End of Anaerobic	4 hr	6377294440	243.7	0	0.0	17260157	1.1	1.164	35.76
				End of Aerobic	6 hr	6441725036	246.1	188674712	4.3	725441683	13.0	0.071	2.48
				End of Settling	8 hr	6553391763	250.4	185443858	4.3	844270868	15.0	0.095	3.21
B1	480	3000	300	End of Feeding	2 hr	463427330	215.8	0	0.0	3630164	0.8	1.533	46.99
				End of Anaerobic	4 hr	438079340	204.2	0	0.0	2413048	0.8	1.726	52.87
				End of Aerobic	6 hr	513179469	238.6	6113100	0.1	17456452	13.0	1.098	33.75
				Extended Aeration	(4hr)	462727593	215.5	6404243	0.1	36280666	16.8	0.914	28.15
				End of Settling	8 hr	450324509	209.8	5303037	0.1	37543352	17.0	0.951	29.27
B2	480	3000	300	End of Feeding	2 hr	452867340	211.0	0	0.0	3064266	0.8	1.121	34.45
				End of Anaerobic	4 hr	449852557	209.6	0	0.0	3821042	0.8	0.781	24.10
				End of Aerobic	6 hr	459282056	213.9	9635275	0.2	10084217	11.5	0.754	23.28
				End of Settling	8 hr	459889036	214.2	5272664	0.1	8990648	11.2	0.797	24.59
B3	480	3000	300	End of Feeding	2 hr	456854052	212.8	0	0.0	5131448	0.9	1.247	38.28
				End of Anaerobic	4 hr	438048021	204.2	1322995	0.0	2745177	0.8	1.195	36.70
				End of Aerobic	6 hr	453387705	211.2	6628273	0.2	15231488	12.5	0.635	19.65
				End of Settling	8 hr	475054249	221.1	11525301	0.3	22687303	14.0	1.317	40.42
				stand 2		2509698171	96.07	434368072	9.96	503394837	9.26		
				Stand 3		5262303226	201.1	908908419	20.8	1109913718	19.5		
				stand 4		7839759641	299.5	1.693E+09	38.8	2358731472	40.5		
				Standards used									
				STD 1		2484184	0	0	0	71633	0	0.163	5
				STD 2		2578366836	100	442549719	10	510852474	10	0.628	20
				STD 3		5272237045	200	913151766	20	1106408486	20	1.149	35
				STD 4		7838874180	300	1.722E+09	40	2352579746	40	1.631	50



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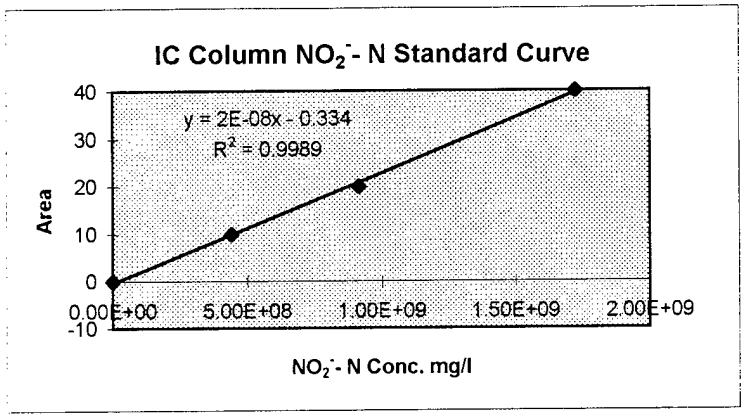

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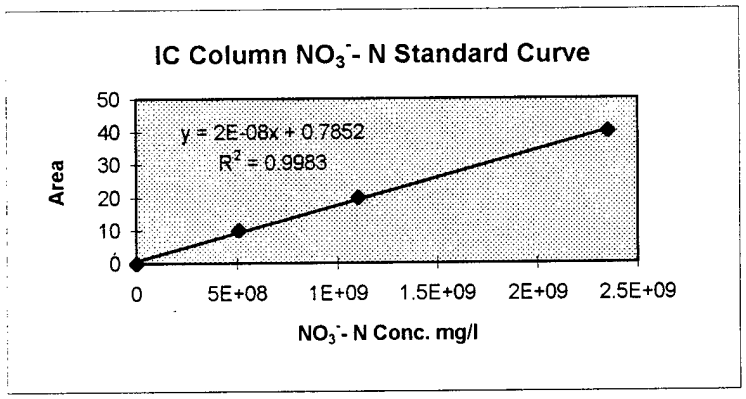

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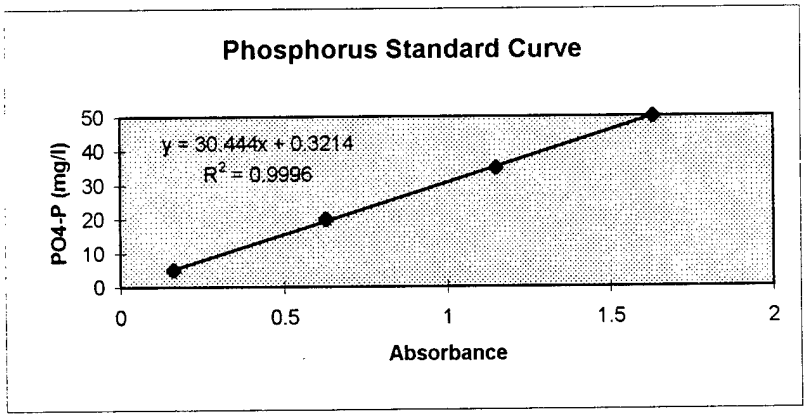


SUMMARY OUTPUT

CL

Regression Statistics	
R Square	0.999911804
Observations	4

	Coefficients	*tandard Error*
Intercept	0.298112729	1.24079601
X Variable 1	3.81601E-08	2.5342E-10

SUMMARY OUTPUT

NO2-N

Regression Statistics	
R Square	0.996872207
Observations	4

	Coefficients	*tandard Error*
Intercept	0	0.55036653
X Variable 1	2.29215E-08	5.5073E-10

SUMMARY OUTPUT

NO3-N

Regression Statistics	
R Square	0.998291554
Observations	4

	Coefficients	*tandard Error*
Intercept	0.785241086	0.65262939
X Variable 1	1.68414E-08	4.9265E-10

SUMMARY OUTPUT

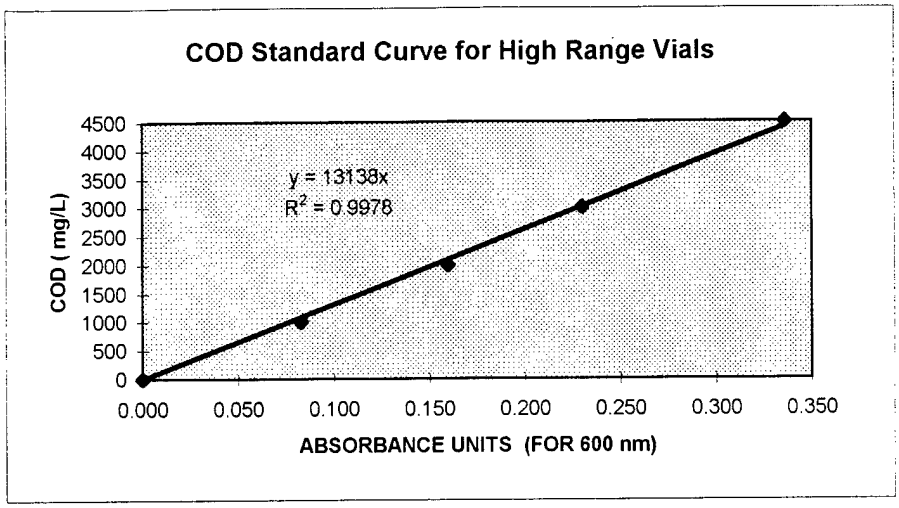
PO4-P

Regression Statistics	
R Square	0.999568534
Observations	4

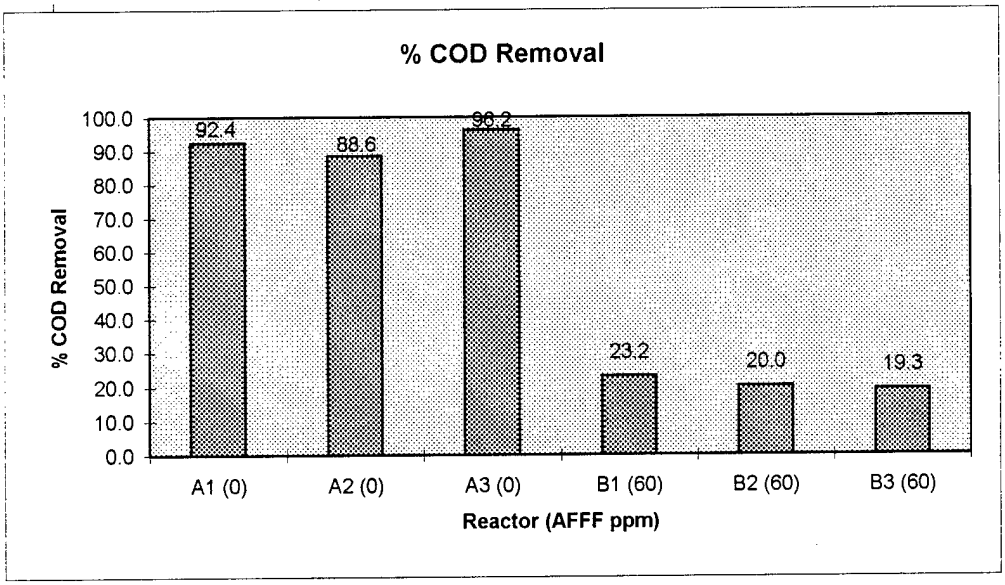
	Coefficients	*tandard Error*
Intercept	0.32137639	0.46914916
X Variable 1	30.44371169	0.44724934

Reactor	AFFF (ppm)	H2O2 mg/l	Fe3+ mg/l	Stage	Time	COD ABS	COD (mg/L)	COD % COD Removal
				Feedstock		0.079	**1037.9**	
				RR Decant		0.001	**13.1**	
A1	0	0	0	End of Feeding	2 hr	0.006	**78.8**	77.2
				End of Anaerobic	4 hr	0.006	**78.8**	77.2
				End of Aerobic	6 hr	0.004	**52.6**	84.8
				Extended Aeration	(4hr)	0.001	13.1	96.2
				End of Settling	8 hr	0.002	26.3	**92.4**
A2	0	0	0	End of Feeding	2 hr	0.017	**223.3**	35.4
				End of Anaerobic	4 hr	0.004	**52.6**	84.8
				End of Aerobic	6 hr	0.004	52.6	84.8
				End of Settling	8 hr	0.003	39.4	**88.6**
A3	0	0	0	End of Feeding	2 hr	0.008	**105.1**	69.6
				End of Anaerobic	4 hr	0.004	**52.6**	84.8
				End of Aerobic	6 hr	0.001	13.1	96.2
				End of Settling	8 hr	0.001	13.1	**96.2**
B1	480	3000	300	End of Feeding	2 hr	0.232	**3048.0**	9.1
				End of Anaerobic	4 hr	0.217	**2850.9**	15.0
				End of Aerobic	6 hr	0.202	2653.9	20.8
				Extended Aeration	(4hr)	0.195	2561.9	23.6
				End of Settling	8 hr	0.196	2575.0	**23.2**
B2	480	3000	300	End of Feeding	2 hr	0.240	**3153.1**	5.9
				End of Anaerobic	4 hr	0.219	**2877.2**	14.2
				End of Aerobic	6 hr	0.210	2759.0	17.7
				End of Settling	8 hr	0.204	2680.2	**20.0**
B3	480	3000	300	End of Feeding	2 hr	0.220	**2890.4**	13.8
				End of Anaerobic	4 hr	0.220	**2890.4**	13.8
				End of Aerobic	6 hr	0.221	2903.5	13.4
				End of Settling	8 hr	0.206	2706.4	**19.3**
				STD 1		0.000	0	
				STD 2		0.083	1000	
				STD 3		0.160	2000	
				STD 4		0.230	3000	
				STD 5		0.336	4500	
				FS (Filtered)**		0.079	1037.9	
				FS Average**		**0.079**	1037.9	
				RRSU(Filtered)**		0.001	13.1	
				RRSU Average**		**0.001**	13.1	

* The values of "COD % Removal" shown in table and chart above are accumulative figures based on the initial COD concentration at time 0 hr.



Reactor (AFFF ppm)	A1 (0)	A2 (0)	A3 (0)	B1 (60)	B2 (60)	B3 (60)
% COD Removal	92.4	88.6	96.2	23.2	20.0	19.3



m = 13138
i = 0

Fentons Pretreatment

For AFFF ppm	480 Reactor 1	480 Reactor 2	480 Reactor 3
Tap water	1250 ml	1250 ml	1250 ml
Actual AFFF ppm	1200	1200	1200
	40 ml	40 ml	40 ml
H202, 3000*2.5 mg/l	7500 mg/l	7500 mg/l	7500mg/l
Fe3+ 300*2.5	750 mg/l	750 mg/l	750 mg/l
FeSO4 (3times)	3723.28 mg/l	3723.28 mg/l	3723.28 mg/l

Initial COD

	Dilution Factor	Absorbance	COD mg/l	Actual COD
AFFF - 480 ppm	33%	0.334	**4388.1**	13164.276

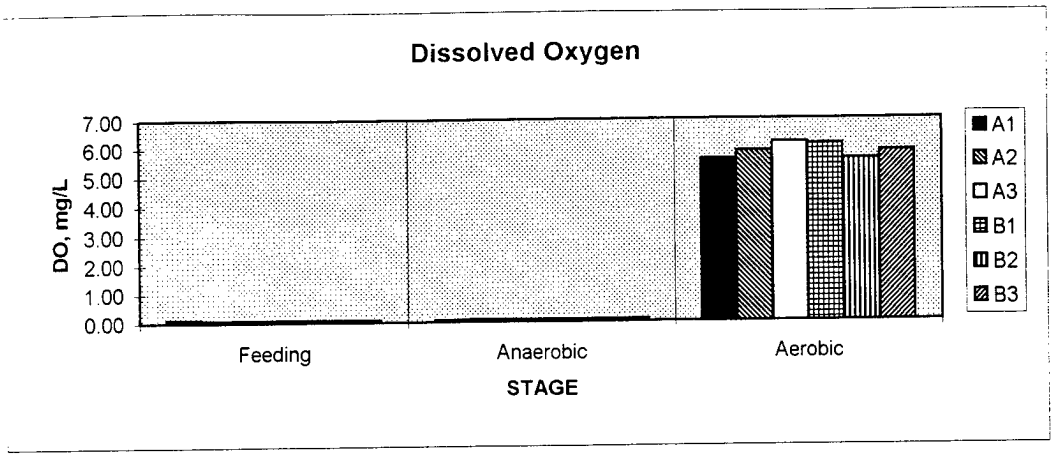
COD after 24 hr reaction period between fentons reagent and AFFF

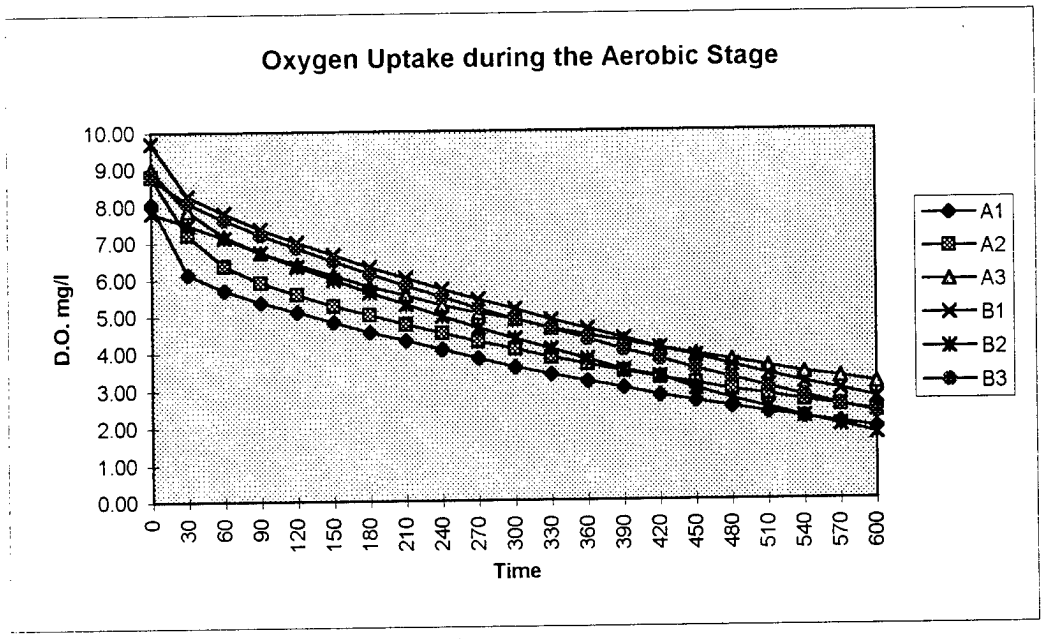
	Dilution Factor	Absorbance	COD mg/l	Actual COD
	50%	0.343	**4506.3**	9012.668

% COD Removal 31.54

Initial COD at Time 0 hr.

Sample	Constituent	Vol (L)	COD mg/L	
Controls	RR Decant	4	13.1	
(A1,A2&A3)	Feedstock	2	1037.9	2075.804
	AFFF	0	0	0
	Total	6		**346.0**
Inhibition	RR Decant	4	13.1	13.1
(B1,B2&B3)	Feedstock	2	1037.9	2075.804
Fentons treated AFFF		2	9012	18024
	Total	6		**3352.2**


Dissolved Oxygen
DO, mg/L
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Feeding
Anaerobic
Aerobic
STAGE
A1
A2
A3
B1
B2
B3


Oxygen Uptake during the Aerobic Stage
D.O. mg/l
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
30
60
90
120
150
180
210
240
270
300
330
360
390
420
450
480
510
540
570
600
Time
A1
A2
A3
B1
B2
B3

Date of Test: 3-25-97

AFFF Conc. 60 ppm

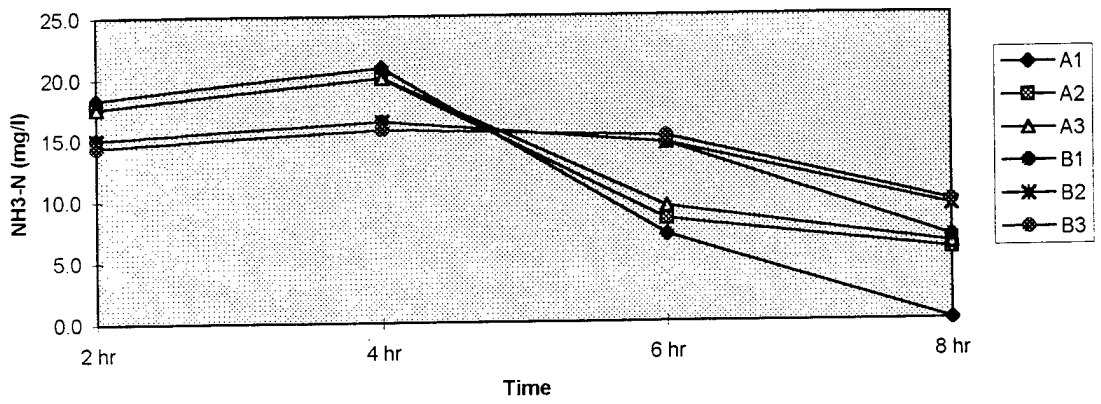
	Dissolved Oxygen (mg/L) at various stages					
Stage	A1	A2	A3	B1	B2	B3
Feeding	0.11	0.09	0.09	0.09	0.08	0.10
Anaerobic	0.07	0.08	0.09	0.09	0.10	0.09
Aerobic	5.58	5.84	6.17	6.10	5.57	5.85

		Dissolved Oxygen in mg/L					
Stage	Time (sec)	A1	A2	A3	B1	B2	B3
Aerobic	0	8.06	8.80	8.99	9.71	7.82	8.78
	30	6.14	7.21	7.88	8.27	7.50	8.08
	60	5.70	6.36	7.17	7.80	7.12	7.63
	90	5.36	5.91	6.72	7.37	6.73	7.22
	120	5.11	5.58	6.39	7.01	6.34	6.84
	150	4.82	5.27	6.09	6.65	5.98	6.48
	180	4.55	5.01	5.79	6.31	5.63	6.13
	210	4.32	4.76	5.54	6.01	5.30	5.80
	240	4.07	4.51	5.27	5.69	4.97	5.49
	270	3.83	4.28	5.06	5.42	4.66	5.18
	300	3.59	4.07	4.88	5.15	4.36	4.88
	330	3.40	3.85	4.64	4.86	4.08	4.61
	360	3.20	3.66	4.45	4.61	3.80	4.33
	390	3.03	3.47	4.27	4.36	3.51	4.05
	420	2.83	3.30	4.09	4.09	3.32	3.79
	450	2.66	3.13	3.92	3.86	2.99	3.52
	480	2.51	2.97	3.77	3.62	2.72	3.27
	510	2.36	2.82	3.59	3.38	2.47	3.03
	540	2.21	2.66	3.42	3.16	2.23	2.78
	570	2.08	2.52	3.29	2.96	2.00	2.55
	600	1.94	2.37	3.14	2.74	1.77	2.33

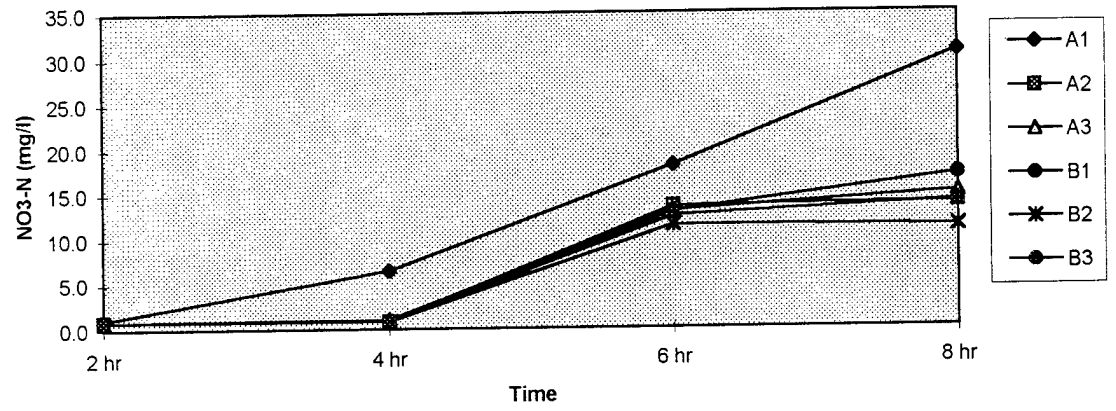
Reactor	AFFF (ppm)	H2O2 mg/l	Fe3+ mg/l	Stage	Time	Concentration, mg/L							
						TKN	NH3-N	Org. N	NO2--N	NO3--N	Total N	Cl-	PO4-P
				Feedstock		39.2	23.3	15.9	0.0	0.9	40.1	267.2	11.5
				RR Decant		1.5	0.2	1.3	0.0	3.4	4.8	234.7	2.1
A1	0	0	0	End of Feeding	2 hr	15.3	18.3	-3.1	0.0	1.1	16.3	242.3	27.4
				End of Anaerobic	4 hr	18.1	20.8	-2.7	0.4	6.5	25.0	241.3	32.8
				End of Aerobic	6 hr	3.7	7.1	-3.4	4.8	18.1	26.6	250.8	6.3
				Extended Aeration	(4hr)	0.7	0.2	0.5	0.7	28.8	30.2	243.0	3.6
				End of Settling	8 hr	2.1	0.1	2.1	0.0	30.7	32.8	246.2	1.1
A2	0	0	0	End of Feeding	2 hr	14.4	17.6	-3.2	0.0	0.9	15.3	240.5	34.7
				End of Anaerobic	4 hr	15.2	20.0	-4.8	0.0	0.9	16.1	240.0	38.8
				End of Aerobic	6 hr	2.4	8.3	-5.9	5.2	13.5	21.1	247.0	10.2
				End of Settling	8 hr	5.3	5.8	-0.4	4.6	13.9	23.8	241.6	4.7
A3	0	0	0	End of Feeding	2 hr	14.4	17.6	-3.2	0.0	0.9	15.3	244.7	32.0
				End of Anaerobic	4 hr	15.2	20.0	-4.8	0.0	1.1	16.3	243.7	35.8
				End of Aerobic	6 hr	3.9	9.4	-5.5	4.3	13.0	21.2	246.1	2.5
				End of Settling	8 hr	5.7	6.2	-0.6	4.3	15.0	24.9	250.4	3.2
B1	480	3000	300	End of Feeding	2 hr	13.6	15.0	-1.4	0.0	0.8	14.4	215.8	47.0
				End of Anaerobic	4 hr	13.5	16.4	-2.9	0.0	0.8	14.4	204.2	52.9
				End of Aerobic	6 hr	11.8	14.6	-2.8	0.1	13.0	24.9	238.6	33.7
				Extended Aeration	(4hr)	12.5	10.1	2.4	0.1	16.8	29.4	215.5	28.1
				End of Settling	8 hr	9.0	6.8	2.3	0.1	17.0	26.1	209.8	29.3
B2	480	3000	300	End of Feeding	2 hr	12.8	15.0	-2.2	0.0	0.8	13.6	211.0	34.4
				End of Anaerobic	4 hr	13.5	16.4	-2.9	0.0	0.8	14.4	209.6	24.1
				End of Aerobic	6 hr	12.5	14.6	-2.1	0.2	11.5	24.2	213.9	23.3
				End of Settling	8 hr	16.1	9.3	6.8	0.1	11.2	27.5	214.2	24.6
B3	480	3000	300	End of Feeding	2 hr	13.6	14.4	-0.8	0.0	0.9	14.5	212.8	38.3
				End of Anaerobic	4 hr	15.2	15.8	-0.6	0.0	0.8	16.1	204.2	36.7
				End of Aerobic	6 hr	11.1	15.1	-4.0	0.2	12.5	23.8	211.2	19.7
				End of Settling	8 hr	12.8	9.7	3.1	0.3	14.0	27.1	221.1	40.4

Reactor	H2O2 mg/l	Fe3+ mg/l	AFFF (ppm)	Stage	Time	Concentration, mg/L BOD	COD	TOC	Alkalinity HCO3 (mg/l)
				Feedstock			1037.9	403.3	510.0
				RR Decant			13.1	12.7	300.0
A1	0	0	0	End of Feeding	2 hr		78.8	**15.9**	533.0
				End of Anaerobic	4 hr		78.8	**16.3**	557.0
				End of Aerobic	6 hr		52.6	**14.5**	371.0
				Extended Aeration	(4hr)		13.1	**13.7**	273.0
				End of Settling	8 hr		26.3	**14.6**	267.0
A2	0	0	0	End of Feeding	2 hr		223.3	**15.5**	520.0
				End of Anaerobic	4 hr		52.6	**16.3**	547.0
				End of Aerobic	6 hr		52.6	**14.1**	407.0
				End of Settling	8 hr		39.4	**14.1**	367.0
A3	0	0	0	End of Feeding	2 hr		105.1	**16.0**	527.0
				End of Anaerobic	4 hr		52.6	**15.7**	521.0
				End of Aerobic	6 hr		13.1	**13.9**	397.0
				End of Settling	8 hr		13.1	**13.9**	373.0
B1	3000	300	480	End of Feeding	2 hr		3048.0	**854.6**	577.0
				End of Anaerobic	4 hr		2850.9	**793.3**	548.0
				End of Aerobic	6 hr		2653.9	**807.1**	567.0
				Extended Aeration	(4hr)		2561.9	**830.8**	504.0
				End of Settling	8 hr		2575.0	**828.2**	477.0
B2	3000	300	480	End of Feeding	2 hr		3153.1	**786.8**	593.0
				End of Anaerobic	4 hr		2877.2	**823.7**	564.0
				End of Aerobic	6 hr		2759.0	**797.4**	550.0
				End of Settling	8 hr		2680.2	**834.5**	534.0
B3	3000	300	480	End of Feeding	2 hr		2890.4	**802.0**	577.0
				End of Anaerobic	4 hr		2890.4	**805.4**	542.0
				End of Aerobic	6 hr		2896.0	787.0	555
				End of Settling	8 hr		2694.3	832.8	620
				FS1				395.1	
				FS2				411.0	
				FS3				403.8	
				FS Avarage				403.3	
				RRSU1				13.5	
				RRSU2				12.6	
				RRSU3				12.1	
				RRSU Avarage				12.71	

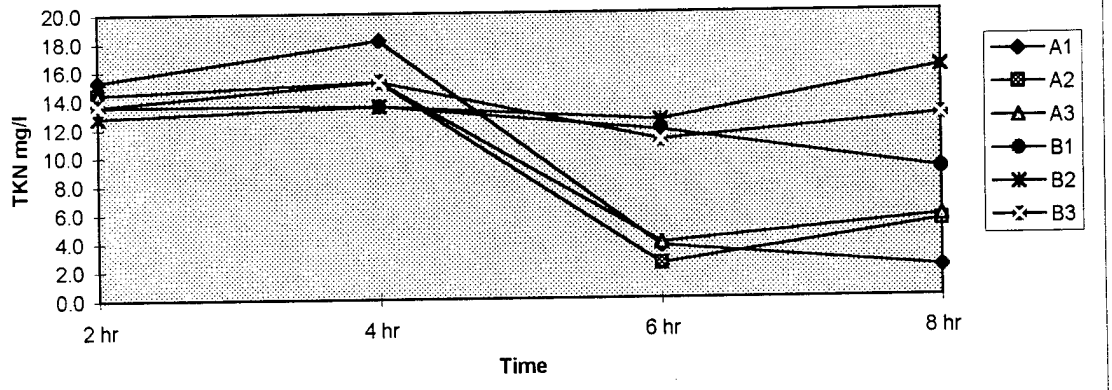
Inhibition Effect of AFFF on Nitrification in terms of NH3-N

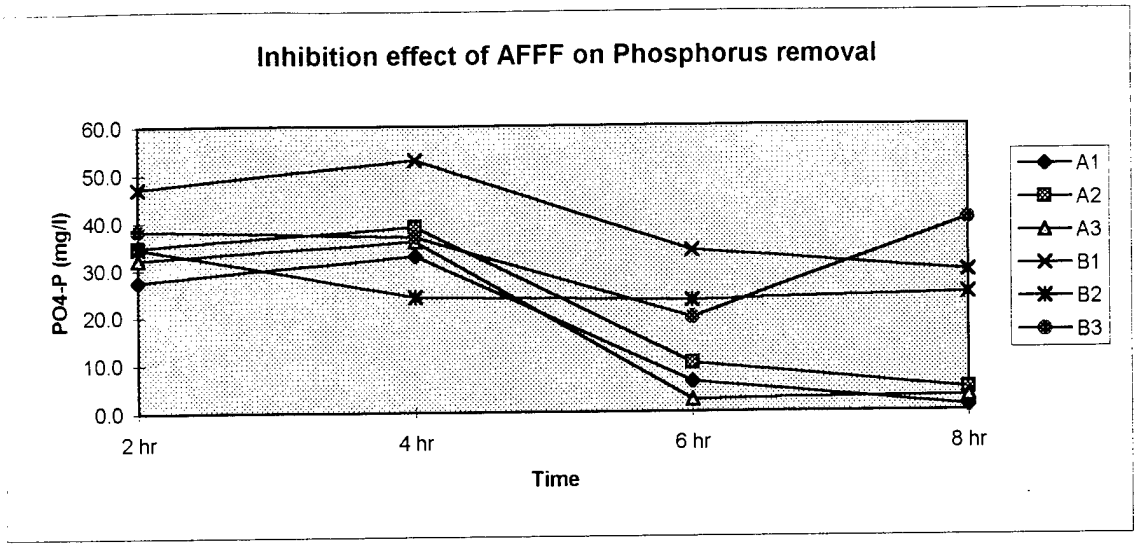


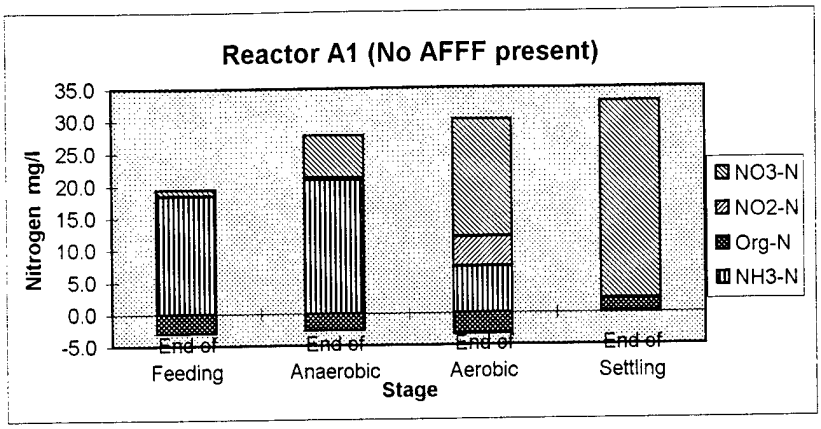
Inhibition effect of AFFF on Nitrification in terms of NO3-N

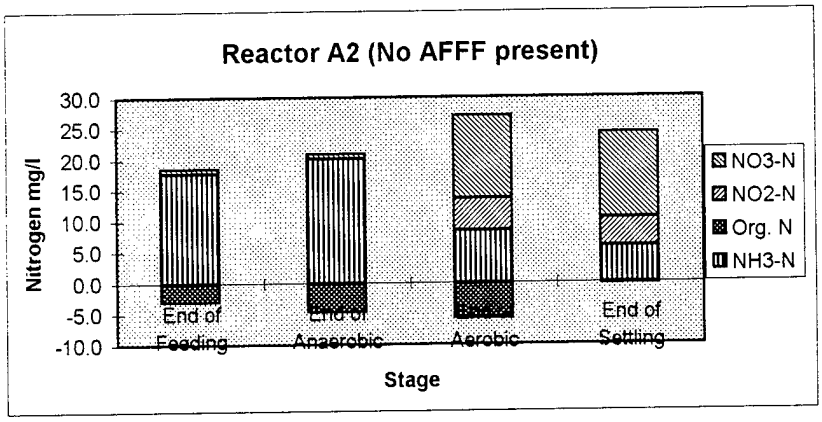


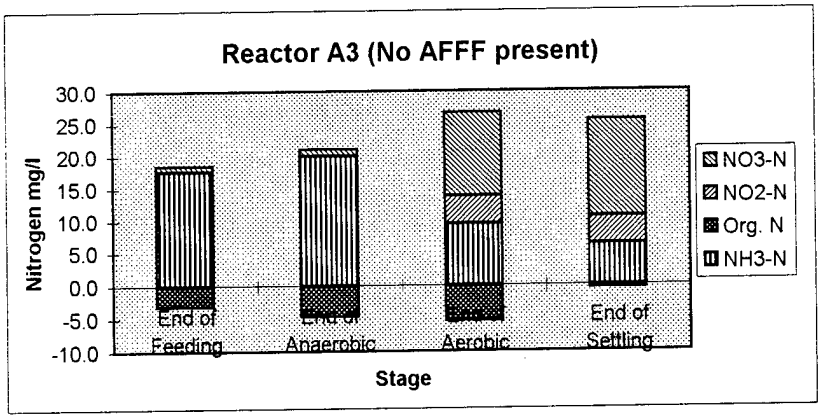
Inhibition effect of AFFF on Nitrification as of TKN

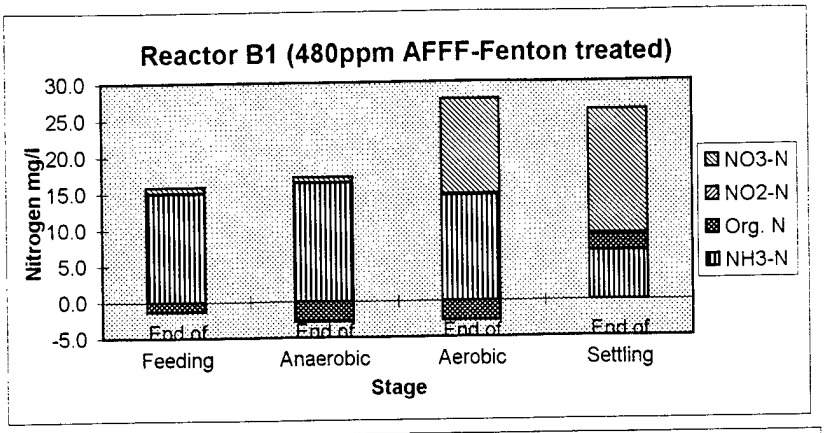


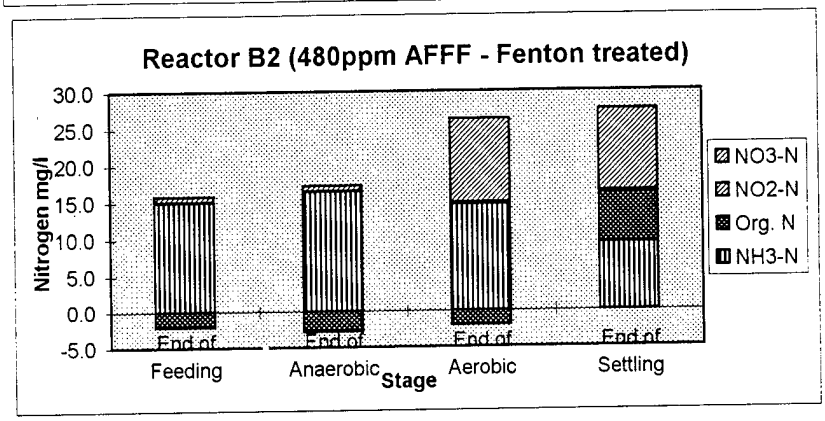

Inhibition effect of AFFF on Phosphorus removal
PO4-P (mg/l)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2 hr
4 hr
6 hr
8 hr
Time
A1
A2
A3
B1
B2
B3

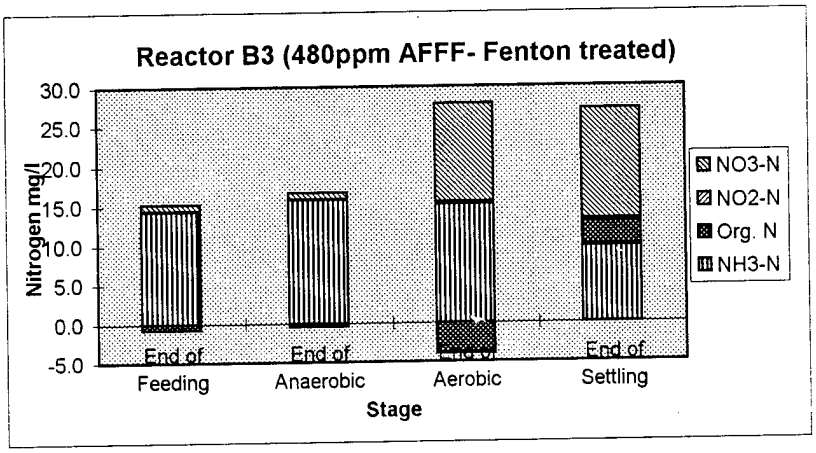

Reactor A1 (No AFFF present)
Nitrogen mg/l
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org-N
NH3-N


Reactor A2 (No AFFF present)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
End of Feeding
End of Anaerobic
Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

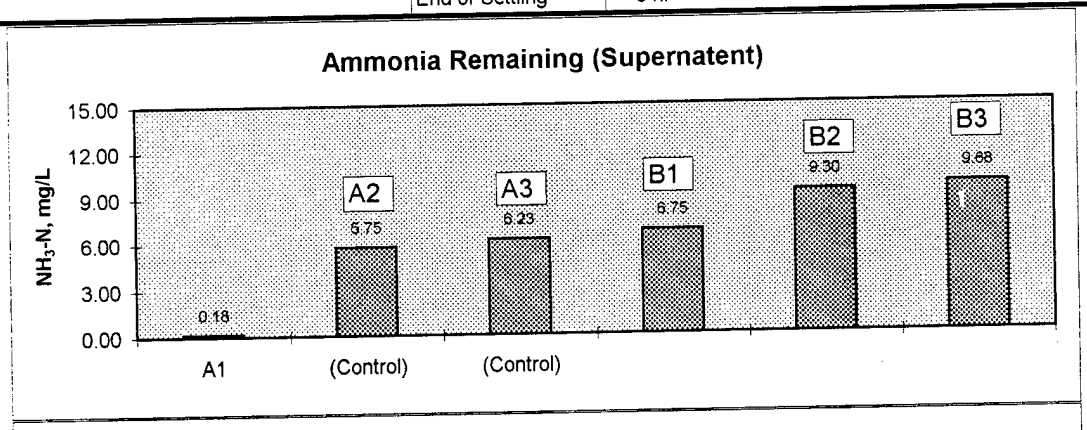

Reactor A3 (No AFFF present)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
End of Feeding
End of Anaerobic
Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

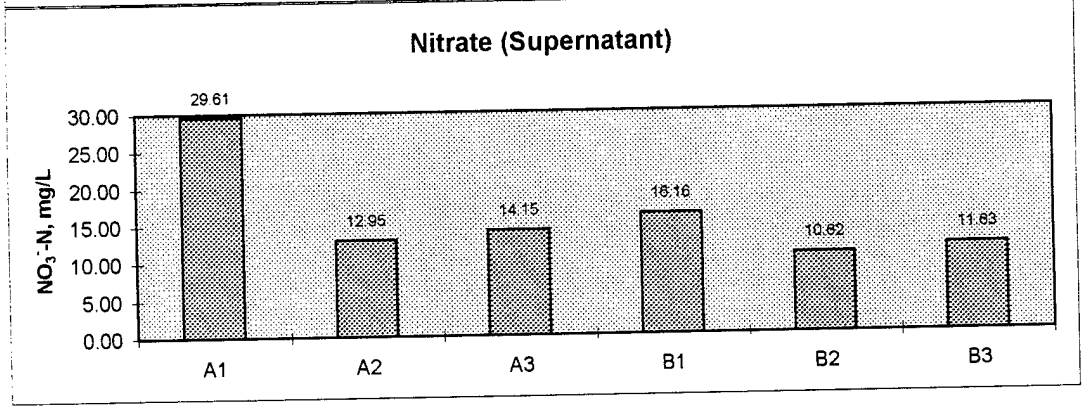

Reactor B1 (480ppm AFFF-Fenton treated)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N


Reactor B2 (480ppm AFFF - Fenton treated)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
End of Feeding
End of Anaerobic
End of Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N


Reactor B3 (480ppm AFFF- Fenton treated)
Nitrogen mg/l
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
End of Feeding
End of Anaerobic
Aerobic
End of Settling
Stage
NO3-N
NO2-N
Org. N
NH3-N

Reactor	AFFF ppm	H2O2 mg/l	Fe3+ mg/l	Stage	Time	Nitrogen Concentration, mg/L NH3-N	NO3--N	NO2--N	Δ(NO_3^--N)
A1 (Control)	0	0	0	End of Feeding	2 hr	18.34	1.1	0.0	
				End of Anaerobic	4 hr	20.83	6.5	0.4	
				End of Aerobic	6 hr	7.09	18.1	4.8	
				Extended Aeration	(4hr)	0.18	28.8	0.7	
				End of Settling	8 hr	0.05	30.7	0.0	29.61
A2 (Control)	0	0	0	End of Feeding	2 hr	17.62	0.9	0.0	
				End of Anaerobic	4 hr	20.02	0.9	0.0	
				End of Aerobic	6 hr	8.32	13.5	5.2	
				End of Settling	8 hr	5.75	13.9	4.6	12.95
A3 (Control)	0	0	0	End of Feeding	2 hr	17.62	0.9	0.0	
				End of Anaerobic	4 hr	20.02	1.1	0.0	
				End of Aerobic	6 hr	9.38	13.0	4.3	
				End of Settling	8 hr	6.23	15.0	4.3	14.15
B1	480	3000	300	End of Feeding	2 hr	15.00	0.8	0.0	
				End of Anaerobic	4 hr	16.40	0.8	0.0	
				End of Aerobic	6 hr	14.55	13.0	0.1	
				Extended Aeration	(4hr)	10.08	16.8	0.1	
				End of Settling	8 hr	6.75	17.0	0.1	16.16
B2	480	3000	300	End of Feeding	2 hr	15.00	0.8	0.0	
				End of Anaerobic	4 hr	16.40	0.8	0.0	
				End of Aerobic	6 hr	14.55	11.5	0.2	
				End of Settling	8 hr	9.30	11.2	0.1	10.62
B3	480	3000	300	End of Feeding	2 hr	14.41	0.9	0.0	
				End of Anaerobic	4 hr	15.76	0.8	0.0	
				End of Aerobic	6 hr	15.14	12.50	0.20	
				End of Settling	8 hr	9.68	14.01	0.30	11.63





BNR Inhibition Tests - 480 ppm AFFF Pretreated with Fenton's Reagent (Nov/24/97)

TSS Reactor	Initial wt	Final wt	Volume	MLSS	WT @ 550 C	MLVSS
A1	1.0988	1.1388	15	2667	1.1022	2440
A2	1.0995	1.1384	15	2593	1.1022	2413
A3	1.0993	1.1381	15	2587	1.1024	2380
B1	1.1159	1.1482	15	2153	1.1193	1927
B2	1.1194	1.1546	15	2347	1.1235	2073
B3	1.1116	1.149	15	2493	1.1152	2253

TDS Reactor	Initial wt	Final wt	Volume	TDS
A1	0.9889	1.005	15	1073
A2	1.0009	1.017	15	1073
A3	0.9991	1.0157	15	1107
B1	1.0209	1.0734	15	3500
B2	1.0178	1.0777	15	3993
B3	1.0233	1.066	15	2847

TS Reactor	Initial wt	Final wt	Volume	TS	ΣTSS,TDS
A1	1.0086	1.0599	15	3420	3740
A2	1.0147	1.0656	15	3393	3667
A3	1.0096	1.0618	15	3480	3693
B1	1.0182	1.1181	15	6660	5653
B2	1.0234	1.1296	15	7080	6340
B3	1.0263	1.1265	15	6680	5340

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13. ABSTRACT (Maximum 200 words)

This report discusses the results of a bench scale study conducted to evaluate the potential inhibitory effects of pretreated AFFF wastewater to the Virginia Initiative Plant (VIP) biological nutrient removal process. The pretreatment scenarios included use of defoamers and use of Fenton's reagent as a strong oxidant. Under this testing, bench-scale reactors simulating the nitrification process were loaded with three AFFF concentrations that were pretreated by defoamers and three AFFF concentrations treated with Fenton's reagent. The pretreatment results with defoamers demonstrated that effluent ammonia nitrogen concentrations for Defoamer # 8710 were higher than the effluent ammonia levels for the Defoamer AF 9020 indicating a better pretreatment and less nitrification inhibition for the latter defoamer. Fenton's reagent was used to pretreat AFFF at concentrations 60 ppm, 120 ppm, and 480 ppm. There were no nitrification inhibition at 60 ppm and 120 ppm AFFF wastewater pretreated with the Fenton's reagent as compared to the controls. Oxidation with Fenton's reagent was more effective than the defoamers used in pretreating AFFF. The nitrification inhibition potential decreased at concentrations greater than 60 ppm however, nitrification inhibition occurred at 480 ppm AFFF pretreated with Fenton's reagent. In all of the pretreatment alternatives used, the inhibition reactor effluents exhibited pass-through toxicity to mysid shrimp at AFFF concentrations 60 ppm or greater, whereas the effluent was not toxic to the sheepshead minnows.

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